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ANNUAL HISTORICAL REPORT
CALENDAR YEAR 1993

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

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UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

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Natick, MA 01760-5007

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13. ABSTRACT *(Maximum 200 words)*

This report contains information concerning the mission, organization, key staff, overall funding and significant research accomplishments of the US Army Research Institute of Environmental Medicine, a subordinate element of the US Army Medical Research and Development Command, for calendar year 1992. Also included are listings of published reports, abstracts, presentations and key briefings for each Research Division of the Institute and significant accomplishments and appointments of the professional staff.

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ANNUAL HISTORICAL REPORT - AMEDD ACTIVITIES

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U.S. ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

NATICK, MA 01760-5007

CALENDAR YEAR 1993

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TABLE OF CONTENTS

	PAGE
General Information	1
Mission	3
Personnel	4
Key Staff	5
Allocation and Funding	7
Supply and Maintenance Activities	8
Building and Facility Equipment	9
Office of the Commander	10
Experimental Pathophysiology Directorate	20
Comparative Physiology Division	24
Cellular Physiology & Pathology Division	35
Environmental Physiology & Medicine Directorate	41
Altitude Physiology & Medicine Division	48
Biophysics & Biomedical Modeling Division	60
Thermal Physiology & Medicine Division	74
Occupational Health & Performance Directorate	90
Military Nutrition Division	97
Military Performance & Neuroscience Division	115
Occupational Medicine Division	130
Occupational Physiology Division	149
Research Programs and Operations Division	161
Appendix A	164
Distribution	165

GENERAL INFORMATION

ORGANIZATION

The United States Army Research Institute of Environmental Medicine (USARIEM) is organized with an Office of the Commander, the Military Detachment, three Research Directorates, a Research Programs and Operations Division and an Administrative Support Division. The organization chart of USARIEM is attached as Appendix A.

The three Research Directorates were organized on 1 October 1990 to consolidate eight Research Divisions, as follows:

a. The Environmental Pathophysiology Directorate, Dr. Roger W. Hubbard, Director. The Directorate incorporates the Cellular Physiology and Pathology Division and the Comparative Physiology Division.

b. The Environmental Physiology and Medicine Directorate, Dr. Kent B. Pandolf, Director. The Directorate incorporates the Altitude Physiology and Medicine Division, the Biophysics and Biomedical Modeling Division, and the Thermal Physiology and Medicine Division.

c. The Occupational Health and Performance Directorate, Dr. James A. Vogel, Director. The Directorate incorporates the Military Nutrition Division, the Military Performance and Neuroscience Division, the Occupational Medicine Division, and the Occupational Physiology Division.

The Research Programs and Operations Division, Dr. Murray P. Hamlet, Director, incorporates the Research Plans and Operations Branch, the Bioengineering Branch and the Animal Care Branch.

The Administrative Support Division, Bethany L. Cruse, CPT, MS, Chief, incorporates the Resource Management Branch, the Information Management Branch and the Logistics Branch.

USARIEM
CY93

LOCATION

USARIEM is located at the United States Army Natick Research, Development and Engineering Center (NRDEC), in Natick, Massachusetts.

ACTIVATION AND ASSIGNMENT

a. By Section VI, General Order 33, Headquarters, Department of the Army, 20 September 1961, USARIEM was established as Class II activity under the jurisdiction of The Surgeon General, effective 1 July 1961.

b. General Order No. 40, Department of the Army, Office of the Surgeon General, 1 December 1961, assigned USARIEM to the United States Army Medical Research and Development Command, Washington, DC, effective 1 July 1961.

c. The USARIEM was last provisionally reorganized by Memorandum dated 25 September 1990, signed by the Deputy Commander of HQ, United States Army Medical Research and Development Command, effective 1 October 1990.

TENANCY

a. USARIEM is a tenant on the NRDEC installation and receives administrative and logistical support from NRDEC on a reimbursable basis and in accordance with an annually renewed, intra-service support agreement.

b. The Pikes Peak Laboratory Facility, Colorado, is a subordinate activity of USARIEM and is utilized on a seasonal basis when a research requirement exists.

MISSION

To sustain and maximize the health and performance of individual military personnel, crews and troop populations through the conduct of basic and applied research programs in environmental medicine (heat, cold and altitude), and military work performance, training and nutrition. The Institute conducts basic research to elucidate mechanisms and sequelae of environmental stress and injury, and performs applied research to provide preventative and therapeutic countermeasures to the performance decrements, injuries and illnesses associated with military operations which expose forces to a wide spectrum of environmental conditions, physical and mental demands, materiel systems hazards and combat stress. Defines the complex interaction of environmental stress, operational stress and Army systems. Develops, evaluates and assists in the implementation of strategies to protect the soldier and enhance performance. In coordination with the U.S. Army Natick Research, Development and Engineering Center and through liaison with other Federal agencies, conducts research to develop the technology base required to evaluate feeding strategies for operational rations and nutritional supplements to minimize soldier performance decrements under sustained combat conditions. Discharges the Army Surgeon General's responsibilities as DoD executive agent for nutrition. Assists USANRDEC in the development of personal clothing and equipment by assessing the physiological impact of these items under all climatic conditions. Provides technical advice and consultant services to Army commanders, installations and activities in support of the Army Preventive Medicine Program and, on request, to other Federal agencies.

USARIEM
CY93

PERSONNEL

STRENGTH AS OF: 31 December 1993

CIVILIANS	AUTHORIZED	ACTUAL
SES	1	1
GM	9	9
GS	71	65
WG	0	2

OFFICERS	AUTHORIZED	ACTUAL
MC	6	9
MS	12	10
VC	2	2
SP	2	5

ENLISTED	AUTHORIZED	ACTUAL
	49	53

TOTAL:	AUTHORIZED	ACTUAL
	152	156

KEY STAFF AS OF: 31 DECEMBER 1993

Gerald P. Krueger, COL, MS, Ph.D., Commander and Scientific/Technical Director

Gaylord C. Lindsay, III, LTC, MS, Ph.D., Deputy Commander

Robert E. Burr, LTC, MC, M.D., Medical Advisor

Beau J. Freund, MAJ, MS, Ph.D., Executive Officer

Charles L. Burton, CPT, MS, Adjutant/Detachment Commander

Raymond W. Dickinson, SFC, Chief Medical NCO

James A. Vogel, Ph.D., Director, Occupational Health and Performance Directorate

John F. Patton, Ph.D., Chief, Occupational Physiology Division, Occupational Health and Performance Directorate

Bruce H. Jones, LTC, MC, M.D., Chief, Occupational Medicine Division, Occupational Health and Performance Directorate

Eldon W. Askew, COL, MS, Ph.D., Chief, Military Nutrition Division, Occupational Health and Performance Directorate

Harold E. Modrow III, MAJ, MS, Ph.D., Chief, Military Performance & Neuroscience Division, Occupational Health and Performance Directorate

Kent B. Pandolf, Ph.D., Director, Environmental Physiology and Medicine Directorate

Michael N. Sawka, Ph.D., Chief, Thermal Physiology and Medicine Division, Environmental Physiology and Medicine Directorate

Richard R. Gonzalez, Ph.D., Chief, Biophysics and Biomedical Modeling Division, Environmental Physiology and Medicine Directorate

USARIEM
CY93

Allen Cymerman, Ph.D., Chief, Altitude Physiology and Medicine Division, Environmental Physiology and Medicine Directorate

Roger W. Hubbard, Ph.D., Director, Environmental Pathophysiology Directorate

Wilbert D. Bowers, Ph.D., Chief, Cellular Physiology and Pathology Division, Environmental Pathophysiology Directorate

Ralph P. Francesconi, Ph.D., Chief, Comparative Physiology Division, Environmental Pathophysiology Directorate

Murray P. Hamlet, D.V.M., Director, Research Programs and Operations Division and Acquisition Management Liaison Officer

Charles E. Watson, CPT, VC, D.V.M., Chief, Animal Care Branch, Research Programs and Operations Division

John M. Foster, Chief, Bioengineering Branch, Research Programs and Operations Division

Bethany L. Cruse, CPT, MS, Chief, Administrative Support Division and Logistic Branch

Ms. Violet M. Trainer, Chief, Resource Management Branch, Administrative Support Division

Ghislain Busque, SFC, Chief, Information Management Branch, Administrative Support Division

Marie E. Stephens, Personnel and Manpower Section, Resource Management Branch, Administrative Support Division

ALLOCATION AND FUNDING

DA PROJECT NO.	TITLE	FUNDS
3M161101A91C	In-House Laboratory Independent Research	$ 108,000
3M161102BS15	Science Base System Health Hazards Research	1,606,000
3M162787A875	Medical Chemical Defense - Exploratory Development	372,000
3M162787A878	Health Hazards of Military Materiel and Operations	880,000
3M162787A879	Medical Factors Enhancing Soldier Effectiveness	3,199,000
3M263002D819	Field Medical Protection and Human Performance Enhancement - Nonsystems Advanced Development	744,000
3M463807D837	Soldier System Protection - Advanced Development	20,000
3M463807D993	Medical Defense Against Chemical Threats - Advanced Development	192,000
3M263002D995	Medical Chemical Defense Life Support Materiel - Nonsystems Advanced Development	588,000
TOTAL FY93 PROGRAM		$ 7,709,000

USARIEM
CY93

SUPPLY AND MAINTENANCE ACTIVITIES

During CY93, 4,482 requests were processed by the Logistics Branch as indicated below:

Expendable	3,279
Class VIII	161
MSO's	595
Non-Expendable	790
One-Time Service	305
Cylinder Turn-in	35
Continual Service	45
Durables	37
Precious Metal	4
Linen	12
Controlled Substance	8
Adjustments	1

The Biomedical Maintenance Branch performed a total of 4,716 Scheduled Service Actions and sent 424 items to Watertown, MA for calibration.

BUILDING AND FACILITY EQUIPMENT

- Entire roof replaced and sealed.
- Asbestos removed from pipe joints above ceiling and chaseways on first and third floors. This completes asbestos removal project for entire building.
- Logistics storage building installed on loading dock.
- First research study successfully completed in environmental chamber 024.
- Two new environmental animal chambers (TESCOR) installed and accepted.
- Contract awarded to replace central air conditioning absorption chillers with two new electrically operated chillers.
- Contract awarded to update and label all electrical panels.
- Replaced/refurbished passenger/freight elevators.

USARIEM
CY93

OFFICE OF THE COMMANDER

SIGNIFICANT PROFESSIONAL ACTIVITIES:

1. In continuation of the effort directed by the Vice Chief of Staff, Army during Operations Desert Shield/Storm, to provide guidance to small unit leaders to sustain the health and performance of soldiers deployed to harsh environments, this Institute prepared another deployment manual: "Sustaining Health and Performance in the Former Republic of Yugoslavia". This handbook was prepared by the U.S. Army Medical Research and Development Command under the Editorial supervision of the USARIEM Command Group from input provided by the staffs of the Walter Reed Army Institute of Research and USARIEM. Initially 600 copies were distributed to units deployed to Macedonia and to FORSCOM/USAREUR units preparing for deployment to FRY. This handbook is USARIEM Technical Note 93-6, DTIC AD-A266 413.

2. To complement other health and performance guidance published by USARIEM, similar guidance was published for nutrition. "Nutritional Guidance for Military Field Operations," provides unit leaders with guidance to maintain nutrition and health of troops. This USARIEM Technical Note (TN 93-8) has already been adopted by the Army Quartermaster for ration training courses.

3. Demand for the whole series of USARIEM's Tech Notes designed for soldiers and leaders in the field has been extraordinary. The highly successful booklet prepared for Desert Shield (TN 91-1) was prepared in pocket size (TN 91-2) to fulfill the request of General Sullivan, then VCS; 19,000 copies were distributed for Desert Shield/Storm. In FY 93, this important soldier guidance document for desert deployment was reprinted several times (3,000 more copies) at the request of U.S. Forces for use with rotational units deploying to Southwest Asia as residual peacekeeping forces in Kuwait, the Sinai, etc. The 50+ years of USARIEM's research work that went into the preparation of this Desert Shield guidance document, and the fielding of the document itself, were publicly credited by the Army Surgeon General for having minimized heat related casualties during one of

the historically largest US military deployments. These deployment manuals are a testament to the actuality that USARIEM research frequently leads to solutions to Army-wide deficiencies and improves Army Doctrine, Training and Leader Development. These solutions are more economical when compared to Organizational changes or Materiel acquisitions. It is precisely this point, the economics of USARIEM's solutions to Army-wide problems in meeting warfighter needs, which is most appealing in a period of constrained budgets.

4. A second medical officer handbook, USARIEM Technical Note 93-4, "Medical Aspects of Cold Weather Operations: A Handbook for Medical Officers" was prepared and distributed. This technical note provides the latest state-of-the art guidance for medical officers and their staff, on the prevention, identification and treatment of cold injuries. We envisioned the need for cold injury treatment of US and NATO peacekeeping forces, and also for the provision of emergency medical care for innumerable refugee cold injury casualties in the severe Bosnia winters of 1993 and 1994.

In FY 93, both the TN 93-4 on cold injuries, and the previous year's handbook, TN 91-3, on medical treatment of heat illness, were adopted in the curricula of the tri-service Deployment Medicine Course by the Joint Medical Readiness Training Center. These two TNs have become Army Medical Department consensus medical guidance documents, and now serve as the basis for OTSG's proposed revisions of tri-service Technical Bulletins Medical No. 507 on heat and 508 on cold. A similar medical handbook for altitude illness was prepared in FY 93; it will be printed in FY 94.

5. The "Outside-the-Boot Ankle Brace" was adopted and is being used by the Infantry School at Ft. Benning, GA, in the basic Airborne course. The German Army Chief of Staff requested prototypes of the brace from USARIEM and now has the German Airborne Bde testing this same ankle brace.

6. USARIEM's scientists designed and fielded for the U.S. Marine Corps Program Manager-Soldier a technically advanced two-piece bootsock system: a thin polyester liner sock with

a thick outer sock of 50% wool and 50% polypropylene blended into a single thread (patent applied for). USARIEM tested this sock system with Army Rangers and Marines in FY 93, demonstrating significant reductions in the incidence and severity of foot blisters. Cold weather testing is now in progress at the Marine Corps Mountain Warfare Training Center in Bridgeport, CA. This unique sock system is being adopted by the U.S. Marines for type classification. Army Rangers and various SOF groups are beginning to use it with great success. Undoubtedly, the generation of an Army Infantry requirements document for a new bootsock system will follow.

7. USARIEM continued initiatives began in the last CY to interact with SOF, Ranger, Airborne and other rapid deployment units. Researchers from this institute conducted an evaluation of the Special Forces Assessment and Selection Course at Fort Bragg.

8. The Surgeon General's professional short course "Current Concepts in Environmental Medicine" was delivered to 55 AMEDD members at USARIEM, 3-7 May 1993. Didactic units were presented in Effects of Heat, Cold and High Terrestrial Altitude; Epidemiology of Military Training Injuries; Physiological Effects of Back-Packing Heavy Loads; Military Nutritional Needs, Present and Future; and Physical and Psychological Effects of Sustained Operations and Environmental Extremes. BG James Peeke, Commander, 44th Medical Brigade, gave the keynote address.

PUBLICATIONS:

1. Caldwell, J.A., C. O'Hara, J.L. Caldwell, R.L. Stephens and G.P. Krueger. Personality profiles of U.S. Army helicopter pilots screened for special operations duty. Military Psychology, 5:187-199, 1993.

2. Burr, R.E., Medical Aspects of Cold Weather Operations. Natick, MA: US Army Research Institute of Environmental Medicine, Technical Note 93-6, 1993.

3. Burr, R.E., Trenchfoot. Journal of Wilderness Medicine, 4:348-352, 1993.

PRESENTATIONS:

4. Krueger, G.P. Sleep and Fatigue: What We Know From Other Fields. By Carl E. Englund and Gerald P. Krueger. Presentation at Society for Technology in Anesthesia Meeting: Performance Shaping Factors, New Orleans, LA, 18 February 1993.

5. Krueger, G.P. Sustaining Health & Performance During Deployment to Harsh Environments. At the Special Operations Exposition & Trade Show, Tampa, FL, 24 March 1993 and at Fayetteville, NC, 14 July 1993.

6. Krueger, G.P. South Vietnamese Lifestyle, Culture and Hardship: A US Advisor's Perspective on Life in Vietnam - 1971-72. Lecture to political science class: U.S. Involvement in Vietnam, at the University of Maryland, College Park, MD, 15 April 1993.

7. Krueger, G.P. Sustained Performance in Continuous Operations: Workload, Fatigue, Rest and Sleep Needs of Combatants. At US Army Medical Department Current Concepts in Environmental and Operational Medicine Course, Natick, MA, 5 May 1993.

8. Krueger, G.P. Ergonomics and Environmental Medicine Research: Sustaining Health and Performance of Soldiers (including slides and proceedings handout in Russian language). At: International Ergonomics Association Scientific Conference entitled Ergonomics in Russia, the Other Independent States and Around the World: Past, Present and Future, St. Petersburg, Russia, 24 June 1993. Presented again at the State Medical Advance Institute, St. Petersburg, Russia, 24 June 1993.

9. Krueger, G.P. Ergonomics and Environmental Medicine Research: Sustaining Health and Performance of Soldiers & Research Capabilities of the US Army Research Institute of Environmental Medicine (including slides and proceedings handout in Russian language). At: Applied Ergonomics Association Headquarters, Moscow, Russia, 29 June 1993. Presented again at the Moscow State University Department of Medicine, 29 June 1993.

10. Krueger, G.P. Research Applications to Psychological and Physiological Stressors Associated with Military Training, Deployment and Operations. At 1993 NATO Stress Workshop, San Antonio, TX, 9 December 93.

11. Burr, R.E. Human Factors in Military Operations, USUHS, Dept of Military and Emergency Medicine, Bethesda, MD, September 1993.

12. Burr, R.E. Implementation of a Heat Strain Prevention Program at JCADS, Annual Army Preventive Medicine Officer's Conference, Falls Church, VA, September 1993.

13. Burr, R.E. Medical Aspects of Deployment to Harsh Environments, 121st General Hospital Annual Medical Conference, Kansas City, MO, September 1993.

14. Burr, R.E. Management of Heat Strain in Chemical Storage and Demilitarization Operations, Toxic Chemical Training for Medical Support Personnel, Aberdeen Proving Ground, MD, April/October 1993.

15. Burr, R.E. Current Concepts in Environmental Medicine, Emergency Medicine Grand Rounds, Brook Army Medical Center, San Antonio, TX, November 1993.

16. Burr, R.E. Medical Aspects of Cold Weather and High Altitude Operations, USAF Global Medicine Course, Brooks AFB, San Antonio, TX, February 1993; and US Army Flight Surgeon Course, Ft. Rucker, AL, February/August/October 1993.

17. Burr, R.E. Heat Stress: Implications for Emergency Service Workers, Tri-Service Emergency Medicine Symposium, San Antonio, TX, May 1993.

SIGNIFICANT TDY:

Gerald P. Krueger, Ph.D., COL, MS. Served as Army representative on Science Technology Interdependency Group (STIG) Operations Committee Program Review Meeting at NASA Space Center, Houston, TX, 31 January - 2 February 1993.

Gerald P. Krueger, Ph.D., COL, MS. To present paper and attend Society for Technology in Anesthesia Third Meeting, New Orleans, LA, 17-19 February 1993. Participate in AAMI Human Engineering Committee: Human Factors for Design of Medical Devices, New Orleans, LA, 20 February, 1993. Participate in ASBREM JTCG-V Meeting on Operational Medicine at Naval Health Research Center, San Diego, CA 22-24 February 1993.

Gerald P. Krueger, Ph.D., COL, MS. To attend Special Operations Exposition and present speech: "Sustaining Health and Performance During Deployment to Harsh Environments," Tampa, FL, 22-28 March 1993.

Gerald P. Krueger, Ph.D., COL, MS. To attend Personnel Management for Executives Course (PME) II, Lancaster, PA, 19-23 April 1993.

Gerald P. Krueger, Ph.D., COL, MS. To present paper at Scientific Conference: Ergonomics in Russia: Other Independent State Institute for Development of Doctors; visit USSR Cardiology Research Center, St. Petersburg, 19-24 June 1993. Visit/lecture at Specialized Center for Disaster Medicine, Moscow, 25-29 June 1993.

Gerald P. Krueger, Ph.D., COL, MS. To attend and present at the Special Operations Exposition, Fayetville, NC, 12-15 July 1993.

Gerald P. Krueger, Ph.D., COL, MS. To serve as session chairman and attend Space Technology Interdependency Group Space Operations, Application and Research Symposium, NASA, Houston, TX, 3-5 August 1993. Served as Army member of STIG Workshop, Atlanta, GA, 5-6 August 1993.

Gerald P. Krueger, Ph.D., COL, MS. Participated in the JTCG-5 ASBREM briefing to Office of Undersecretary of Defense, Ft. Detrick, Frederick, MD, 25-26 August 1993.

Gerald P. Krueger, Ph.D., COL, MS. To attend and participate in Human Factors and Ergonomics Society 37th Annual Meeting and participated in Executive Session Meetings, Seattle, WA, 11-15 October 1993.

USARIEM
CY93

Gerald P. Krueger, Ph.D., COL, MS. Medical liaison visits to Centre Recherche Service Sante des Armees, Grenoble, France, 1 November 1993; to serve as US National representative to NATO ORG Panel 8 Workshop to produce a "Commanders Guide to Sleep & Wakefulness," Lyon, France, 2-4 November 1993; Centre de Recherche de Medicine Aerospatiale, Breitgny, France, 5 November 1993.

Gerald P. Krueger, Ph.D., COL, MS. To present USARIEM programs on Soldier Stress Research to NATO Stress Workshop, San Antonio, TX, 8-10 December 1993.

Robert E. Burr, M.D., LTC, MC. To instruct at the Global Medicine Course on Cold Injury and High Altitude Effects, USAF School of Aerospace Medicine, Brooks, AFB, TX, 24-26 February 1993.

Robert E. Burr, M.D., LTC, MC. To attend Navy Cold Pathophysiology Program Review, Naval Medical Research and Development Command, Bethesda, MD, 28-29 April 1993.

Robert E. Burr, M.D., LTC, MC. To instruct at Tri-Service Course in emergency medicine, San Antonio, TX, 11-14 May 1993.

Robert E. Burr, M.D., LTC, MC. To assess Heat Stress Prevention Program in support of Phase II Wyoming MOU at Johnston Island, 23-28 May 1993.

Robert E. Burr, M.D., LTC, MC. To teach at Toxic Chemical Training for medical support personnel, Edgewood, MD, 15-17 June 1993.

Robert E. Burr, M.D., LTC, MC. To instruct at the Flight Surgeon Course, Ft. Rucker, AL, 30 July 1993.

Robert E. Burr, M.D., LTC, MC. To present a talk at 102nd ARCOM Medical Symposium, Kansas City, MO, 18-19 September 1993.

Robert E. Burr, M.D., LTC, MC. To present at the Annual Preventive Medicine Officers Symposium, Falls Church, VA, 20-23 September 1993.

Robert E. Burr, M.D., LTC, MC. To teach at the Toxic Chemical Training Course, Edgewood, MD, 19-21 October 1993.

Robert E. Burr, M.D., LTC, MC. To instruct at the US Army Flight Surgeon School, Ft. Rucker, AL, 3-4 November 1993.

Robert E. Burr, M.D., LTC, MC. To present emergency medicine grand rounds at Brook Army Medical Center, San Antonio, TX, 11-12 November 1993.

Gaylord C. Lindsay, III, Ph.D., LTC, MS. To attend the HQDA sponsored Personnel Management for Executives (PME) Course, Lancaster, PA, 2-12 February 1993.

Gaylord C. Lindsay, III, Ph.D., LTC, MS. To participate in ASBREM JTCG-V meeting on operational medicine at the Naval Health Research Center, San Diego, CA, 22-26 February 1993.

Gaylord C. Lindsay, III, Ph.D., LTC, MS. To represent HQ, USAMRDC at the Louisiana Maneuver Exercise Coordination Conference, Ft. Leavenworth, KS, 27-30 April 1993.

Gaylord C. Lindsay, III, Ph.D., LTC, MS. To attend Air Assault School, Ft. Rucker, AL, 23-29 May 1993.

SIGNIFICANT VISITORS:

- Country: Australia
  Names: MAJ Stephan Rudzki
  Purpose: To discuss mutual interests with MAJ Knapik regarding Defence force fellow research training injuries in Australian Army

- Country: Australia
  Names: Mr. Amos Denys
  Purpose: To discuss development and evaluation of microclimate cooling systems worn under NBC clothing

- Country: British
  Names: MAJ John Miller
  Purpose: To discuss mutual interests with COL Krueger

USARIEM
CY93

- Country: Canada
  Names: LCDR William Bateman
  Purpose: To attend the Current Concepts In Environmental Medicine Course

- Country: France
  Names: Loic Langot and Paul Borredon
  Purpose: To discuss mutual interests with COL Krueger

- Country: India
  Names: Dr. W. Selvamurthy
  Purpose: To exchange information on high altitude studies

- Country: India
  Names: Mr. Manoj Sarvamitra Desai
  Purpose: To modify and debugg existing nutrient analysis programs

- Country: Israel
  Names: Prof. Michal Horowitz
  Purpose: Present seminar

- Country: Israel
  Names: Dr. Aharon Levy
  Purpose: Evaluate histological samples and routine collaborative research in military performance and neuroscience

- Country: Israel
  Names: Dr. Yair Shapiro
  Purpose: To discuss potential NRC fellowship

- Country: Portugal
  Names: LTC Pedro Manuel Caimoto Jacome and MAJ Jorge Manuel Espirito Santo
  Purpose: To attend the Current Concepts in Environmental Course

- Country: Russia
  Names: Dr. Victor Koscheyev
  Purpose: To present seminar

- Country: Saudi Arabia
  Names: Dr. Amin Kashmeery
  Purpose: Consult with Dr. Sawka on mutual research

- Country: United Kingdom
  Names: Dr. Peter Cross, Ms. Sarah Cross, M.G. Kalzell, Nigel Gaspar, Neil Wilson and Chris Gooderson
  Purpose: To discuss mutual interests with COL Krueger

- Country: United Kingdom
  Names: COL John D. Sankey
  Purpose: To meet with British liaison officer and his commander officers

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Krueger, Gerald P., Ph.D, COL, MS, Commander. Space Technology Interdependency Group (STIG) Operations Committee (SOC) Aug 92 - Jun 94; Co-Chairman of SOC Human Factors Subcommittee, Aug 93-Jun 94; member Life Sciences Subcommittee; selected as 1 of 7 DoD Members of Human Machine Operations Working Group for National Facilities Planning Study (to review & critique all NASA & DOD human factors & life sciences space research facilities for retention, upgrade, mergers, closure etc.) Aug 93 - Mar 94; US Senior Representative to Ad Hoc Group on Commander's Guide to Sleep and Wakefulness, NATO Defense Research Group, Panel 8, Defense Applications of Human & Biomedical Science, Jan 93 - June 94

Lindsay, Gaylord C., III, Ph.D., LTC, MS, Deputy Commander. USAMRDC Representative to the Louisiana Maneuvers Exercise Coordination Conference. Chairman, Scientific Review Committe and Program and Budget Advisory Committee.

Burr, Robert E., M.D., LTC, MC, Medical Advisor. Instructor in Medicine, University of Massachusetts Medical School.

ENVIRONMENTAL PATHOPHYSIOLOGY DIRECTORATE

RESEARCH FINDINGS: EXECUTIVE SUMMARY

- During 10 days of heat acclimation while consuming either a moderate or restricted salt diet, test subjects successfully completed strenuous 8.5 h daily bouts of intermittent treadmill walking without signs of orthostatic intolerance or syncopal symptoms.

- After 7 days of test subject dietary stabilization, a restricted salt diet significantly reduced plasma volume expansion during the subsequent 4-8 days of heat acclimation, but full expansion was attained by day 10.

- Developed a miniature swine model for the study of deep and prolonged hypothermia and rewarming shock. Splenic contraction was identified as a major contributor to the hemoconcentration attending hypothermia and rewarming.

- Prevention of hemoconcentration by splenectomy of miniature swine appeared to correlate with a significant risk of tachycardia and hypotension during rewarming from deep hypothermia.

- Mesenteric oxygen delivery, extraction and use were determined during induced-cooling (3h), profound, deep-body hypothermia (28°C; 2h) and rewarming (4.5h) in the anesthetized swine model. Cooling reduced whole-body oxygen extraction (35%) which remained depressed (64%) in the gut during rewarming. Gut oxygen use (VO_2) slowly returned to precooling levels during rewarming.

- Heatstroke research has been hampered by lacking a non-pet breed animal model large enough to provide serial blood samples during the induction, duration, and resolution of induced-hyperthermia. The instrumented, anesthetized, passively-heated microswine model was developed in response to this

requirement. The significance of this development was affirmed by invitation for an oral presentation to the prestigious 1994 Army Science Conference.

- The passively-heated heatstroke microswine model has provided an invaluable analog data base on cardiovascular, metabolic, clinical-chemical, and immunological variables during progressive, lethal hyperthermia. Comparison of this data base to a comparable exercising-swine model, now coming on-line, will provide a new experimental basis for unlocking the mechanism of exercise-induced thermal intolerance previously established in rats and humans. This new system lends itself to direct product development and evaluation of potential LPS-binders, anticytokines, membrane stabilizers, and other candidate compounds.

- Doppler flow probes and non-occlusive catheters have remained functional and patent in the renal, mesenteric, iliac, and/or hepatic vascular beds of the conscious rabbit for up to 30 days.

- The conscious instrumented rabbit has been developed as a model to determine the effects of environmental stress on splanchnic organ blood flow and metabolism. In particular, this model lends itself to evaluation of the hypothesis that thermally-driven ion flux stimulates aerobic glycolysis.

- The hypothesis that an adenosine A1 antagonist would improve the exercise capacity of adult rats exercising in the heat by increasing cardiac function produced mixed results. Treated animals manifested improved heart rate and blood pressure responses yet exhausted with elevated plasma lactate levels and accompanying acidosis, suggesting ischemic metabolic effects.

- The proper functioning of the tissue Na/K ATPase (the sodium pump) and its many counterparts are basic enzymatic motors responsible for neural conduction, muscle contraction, metabolic consumption and elimination or, simply put, life itself. Recent reviews from this department have stressed the

potential role of these enzymes in molecular adaptation to heat, cold, and altitude. The quantitation of these pumps with molecular probes will soon document their involvement or not in tissue acclimation to potassium depletion and/or heat acclimation.

- Hyperthermic exposure affects endothelial cell metabolism to reduce the synthesis of prostacyclin, an essential vasoactive element that influences circulation.

- The use of thermoelectric cooler controllers with thermoelectric modules significantly improves the state of the art for the temperature regulation of cell and/or tissue samples exposed to environmental extremes.

- Increased heat tolerance following subchronic anticholinesterase administration resembles changes seen with heat acclimation in rats. This finding implies that a pharmacological approach to an improved heat acclimation status may be militarily relevant.

- HSD treatment increased PV following hyperthermic dehydration which contributed to increased radiant cooling and survival. These militarily relevant results serve to allay fears that HSD treatment could inadvertently worsen heatstroke shock.

- Although research is not complete, exposure of artificial human skin ($Skin^2$) to temperatures from 37° to 43°C for 90 min did not elevate PGE_2, TxB_2 or IL-1α; however, subsequent and more preliminary data from 44° and 45°C suggest a threshold for induction of PGE_2 and IL-1α release.

PUBLICATIONS:

1. Hubbard, R.W., S.L. Gaffin, and J.R.S. Hales. Limits of tolerance to the heat. In: Handbook of Physiology: Adaptation to the Environment, C.M. Blatteis and M.J.

Fregly, Editors, Oxford University Press, New York, NY. (In Press), 1993.

2. Hubbard, R.W., S.L. Gaffin, and D.L. Squire. Heat-related Illnesses. In: Third Edition of Management of Wilderness and Environmental Emergencies, Paul S. Auerbach, M.D., Editor, Mosby-Year Book, Inc. of St. Louis, MO. (In press), 1993.

KEY BRIEFINGS:

3. Roger W. Hubbard, Ph.D. Mr. Herbert S. Hoffman, Civilian Aide to The Secretary of the Army, First U.S. Army Area-East, Mr. Roger Saunders, Civilian Aide for Massachusetts, and LT Michael Finer, USAR, Assistant to Mr. Hoffman. USARIEM, Natick, MA, 8 February 1993.

4. Roger W. Hubbard, Ph.D. Review & Analysis of our Research Programs to COL Schnakenberg, MAJ Leu, RA III: LTC Moore and MAJ Shimomora, RA V; COL Lake, MRDC Comptroller; and COL Tyner, MRDC Deputy Commander. USARIEM, Natick, MA, 11-12 February 1993.

5. Roger W. Hubbard, Ph.D. Colonel G., F. McCauley, Deputy Chief, Defence and Civil Institute of Environmental Medicine (DCIEM), North York, Ontario, Canada. USARIEM, Natick, MA, 6 August 1993.

6. Roger W. Hubbard, Ph.D. Review & Analysis of RA III Research Programs to COL Robert Gifford, Director RA III, and MAJ Karl Friedl, Staff Officer RA III. USARIEM, Natick, MA, 27 October 1993.

SIGNIFICANT VISITORS:

William R. Beisel, M.D., F.A.C.P., Consultant, USAMRDC and Adjunct Professor in the Department of Immunology and Infectious Diseases at the Johns Hopkins University School of Hygiene and Public Health, 15 April 1993.

Colonel Lee and Major Wong, Senior Medical Officers, Republic of Singapore, 12 August 1993.

Dr. Michal Horowitz, Department of Physiology, Hebrew University, Israel, 23 September 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Hubbard, Roger W., Ph.D., Research Director. Member, DOD Steering Committee on Field Water Quality. Adjunct Professor of Pathology, Boston University School of Medicine, Boston, MA. Member, Editorial Board, Journal of Wilderness Medicine. Reviewer, Aviation Space and Environmental Medicine, Journal of Applied Physiology, and Journal of Wilderness Medicine. Appointed Grant Officer's Representative (GOR) on 10 August 1993 for Grant No. DAMD17-93-J-3031, University of Georgia, Principal Investigator - Dr. John S. Willis, Grant Specialist - Kathy A. Hackley.

COMPARATIVE PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. During rapid deployment from garrison to hot environments, either jungle or desert, both caloric and salt intakes are typically reduced while salt losses in sweat are usually increased, particularly during the initial days (d) of heat exposure. The present study was designed to assess the impact of restricted salt (NaCl) intake on the circulatory responses and incidence of syncopal symptoms to upright posture (orthostatic test; OT) during successive days of heat exposure, and to evaluate the effect of heat acclimation (HA) on these responses. Seventeen unacclimated male soldiers (mean ± SE: age, 20±1 yrs) consumed a diet of about 4000 kcal/d containing 8g NaCl (moderate salt, MS) and lived in a dormitory setting (21°C, 30% RH) for a 7 d dietary stabilization period (d 1-7). On d 8, soldiers were randomly assigned either to continue on the MS diet (n=9) or consume a restricted-salt diet (RS, n=8) which provided 4g NaCl/d, and also began a 10 d HA program (d 8-17; 8.5 hr intermittent treadmill

walking/d, 30 min/hr, 5.6 km/hr, 5% grade, 41°C, 21% RH). An OT was performed at 21°C on d 7 of the dietary stabilization period and immediately before and after treadmill walking on d 9, 11, 13, 15, and 17 during HA. Blood pressure (BP) and heart rate responses and any presyncopal symptoms were recorded for 4 min after assuming an upright position from recumbency. All subjects completed the OT before and after prolonged walking in the heat without occurrence of either hypotension or presyncopal symptoms irrespective of salt intake and day of HA. Significantly smaller increases were observed in the RS diet on d 11 (d 4 of HA) in diastolic pressure (RS: 4±2 mmHg; MS: 22±2 mmHg) and mean blood pressure (RS: 6±4 mmHg; MS: 18±1 mmHg) at 2- and 4-min standing post-treadmill walking. Plasma volume expansion was also significantly attenuated in the RS (+2%, d 11; +7%, d 15) compared to the MS diet (+11.5%, d 11; +13%, d 15), although all sweat losses incurred during HA were replaced hourly with equal volumes of pure water. These results indicate that, with adequate fluid replacement, prolonged work in the heat can be performed without orthostatic hypotension or syncope while consuming a RS diet of 4g NaCl/d. Further, the circulatory responses to upright posture showed no significant improvement with successive days of HA irrespective of salt intake.

2. Central arterial hemodynamic changes were assessed during active cooling, hypothermia, and rewarming in splenectomized (SPX, n=4) and unsplenectomized (SP, n=4) 8-10 month old male Yucatan miniature swine (34.0 ± 1.4 kg). Under isoflurane anesthesia, and using circulating-water blankets, pigs were cooled to, and then maintained for 2 hours at a rectal temperature (T_{re}) of 27 ± 1°C; hypothermia was followed by rewarming to normothermia (37 ± 1°C). There were significantly ($p \leq 0.05$) greater changes in central arterial hematocrit and hemoglobin (ΔHCT and ΔHGB) from respective pre-cooling baseline levels in the SP group during hypothermia and early rewarming (SP: ΔHCT_{max} = 9-10% RBC, and ΔHGB_{max} = 3.0-3.5 g/dl vs. SPX: ΔHCT_{max} = 3-4% RBC, and ΔHGB_{max} = 1.5-1.8 g/dl). By the end of the rewarming interval, splenic resequestration and extravascular fluid shifts resulted in these values returning to

baseline. In addition, cardiovascular instability was seen in the SPX group compared to the SP animals as evidenced by significant tachycardia and hypotension during rewarming. We have concluded from these studies that hypothermia causes significant hemoconcentration, and that splenic contraction is the major cause of this hemoconcentration during hypothermia and initial rewarming in miniature swine. A splenectomized design should be considered for swine studies that purport to pattern human pathophysiology, especially for modeling deep hypothermia and rewarming shock.

3. The effects of cooling (3h), hypothermia (T_{rec}=28°C, 2h) and rewarming (4.5h) on mesenteric oxygen delivery (DO_2), O_2 extraction and oxygen use (VO_2) were studied in 7 anesthetized (2-3% isoflurane in air) splenectomized miniswine (36±1 kg). Compared to precooling (T_{rec}=38.1±.2°C), mesenteric O_2 extraction and VO_2 were reduced during cooling and remained depressed during hypothermia (45% and 49% of precool, respectively, $p<.05$) despite minimal change in DO_2. A fall (31%) in gut resistance (R_{mes}) during hypothermia was most likely due to a decrease in mean blood pressure (BP, 7%) and not the small rise in gut blood flow (Q_{mes}, p=ns). Both whole-body O_2 extraction (35%) and heart rate (HR, 17%) were lowered by cooling. During rewarming, R_{mes} continued to fall (45% from precool) without any further increase in Q_{mes}, and probably contributed to the sustained hypotension (25% fall, $p<.05$). After rewarming (37.8±.1°C), both HR and whole-body O_2 extraction increased above precool values (30%, $p<.05$). While gut O_2 extraction remained depressed during rewarming (64% of precool, $p<.05$), gut VO_2 slowly returned toward precool levels as a result of increased arterial O_2 content ($p<.05$). Hematocrit increased (HCT, 12%, $p<.05$) during hypothermia and remained elevated during rewarming indicating intravascular fluid loss. Glucose, alkaline phosphatase and aspartate aminotransferase were elevated in the mesenteric venous blood during rewarming ($p<.05$) indicating hepatic or myocardial effects, although mesenteric venous lactate levels were unchanged. In three control miniswine (33±1 kg) maintained at 38.2±.05°C for 9.5h, no significant changes were seen in circulatory, metabolic or clinical variables in either mesenteric or

whole-body measures. These results show that mesenteric O_2 extraction and VO_2 are reduced during hypothermia and rewarming. Moreover, mesenteric O_2 extraction and VO_2 during rewarming (vs precool) were lower for a given DO_2.

4. Many historical accounts have documented the key role of heat illness in the outcome of military campaigns. Since the pathophysiology of heatstroke (HS) is not fully understood, we recently developed an anesthetized microswine model; this species is large enough (22-46 kg) to permit serial blood sampling to provide extensive new information of the pathophysiology of HS. Microswine were passively heated (T_{env} =41-43°C, RH=60%), and T_{re} rose linearly at the rate of 1.9°C/hour to 45-47°C at mortality over a 3.5-5 hour heating interval, during which multiple blood samples were taken. During the early phase of heating, mean arterial pressure rose slightly, but at T_{re}>41°C it declined continuously to 50% at 43.5°C. Heart rate plateaued at T_{re}=38-43°C, spiked to peak at 44-45°C, then fell precipitously until mortality. Respiratory rate (RR) reached a maximum at 43°C, the same core temperature at which PO_2 began to fall, and minimum PCO_2 and maximum pH were attained. RR then declined with a concomitant decrease in pH (to 6.7) while pCO_2 rose to >200 mm Hg at mortality. Plasma potassium (K^+) virtually doubled during hyperthermia (>7mEq/l). Calcium concentration declined to a minimum at 44-45°C, then rose rapidly to near baseline values before mortality. Lipopolysaccharides (LPS, endotoxin) rose at T_{re}>43.5°C, apparently by elevated leakage from the gut lumen due to thermal and ischemic damage, and may play a role in the pathophysiology of HS as we previously proposed. Glucose increased early and began to fall at T_{re}=44°C, approximately 40 min after an elevation in insulin. Lactate commenced to rise at T_{re}=42.5°C. Several enzymes, including creatine phosphokinase and aspartate aminotransferase, common indices of heat injury, were elevated, but not until T_{re} =44°C. Close examination of the time course of elevations and declines (e.g., K^+, Ca^{++}, glucose) explains some of the controversies in the literature concerning the effects of HS on key clinical chemistry markers, and contribute to our understanding of the pathophysiology of HS. The elevation

in plasma K^+ was probably due to accelerated loss of intracellular K^+ from temperature-induced increases in membrane fluidity and in the number of K^+ channels. The microswine model provides an opportunity to study the time course of multisystemic changes during extreme hyperthermia. This model may be useful in assessing benefits of prospective therapies for heat illnesses, such as dietary manipulation, vaccination, and administration of LPS-binders, cytokines, anticytokines, and membrane stabilizers.

5. Flow probes and non-occlusive catheters were simultaneously implanted in the splanchnic and hindlimb vasculature to measure regional blood flows and arterial-venous differences of individual organs in the conscious rabbit. Pulsed Doppler flow probes were constructed by modifying the technique of Haywood et al. (Am. J. Physiol. 241:H273-78, 1981), and non-occlusive catheters were designed and constructed from Silastic tubing (0.6 mm or 0.9 mm OD) and surgical velour. Under anesthesia, a laparotomy was performed and the renal, mesenteric, iliac, or hepatic artery and portal vein were isolated and instrumented with a flow probe. A non-occlusive catheter was then inserted into the respective vein. Instrumentation of the hepatic system required probes on both the hepatic artery and portal vein, and non-occlusive catheters into both hepatic and portal veins. One week later, rabbits were re-anesthetized and non-occlusive catheters were inserted into the superior vena cava via the jugular vein and abdominal aorta to the level of the coeliac axis. Probes and catheters were evaluated daily up to 30 days. Implants remained functional for an average of three weeks, permitting chronic measurement of velocity and blood variables in individual tissue beds of the conscious rabbit. These sophisticated methodologies will be applied to determining the effects of environmental stress on splanchnic organ blood flow and isolated organ metabolism.

6. Evaluated the hypothesis that elevated circulating adenosine levels during endurance exercise suppress cardiac function and therefore limit increases in cardiac output and reduce performance. Therefore, an adenosine A1 antagonist [NPC 205](1,3-di-n-propyl-8-(4-hydroxyphenyl)

xanthine) was studied to determine the effects of adenosine during exercise in the heat. We previously reported that a 10 mg/kg dosage was apparently excessive, blocked both A1 and A2 receptors, and had no beneficial effects on performance. In the current experiment, we assessed the effects of a lower dosage on the ability of adult male rats (350 g, saline or NPC 205, 1 mg/kg,ip) to exercise (treadmill, 11 m/min, 6° incline) in a warm (30°C) environment. Endurance capacity of saline- and NPC-treated rats was not significantly different. However, the NPC group exhausted at a lower core and tail skin temperature with elevated plasma lactate levels and accompanying acidosis. In apparent contrast, the same NPC group demonstrated improved cardiovascular indices (heart rate and blood pressure). Although the precise mechanism is unclear, it appears that any beneficial cardiovascular effects of NPC were counterbalanced by an exaggerated metabolic response which contributed to exhaustion independent of thermoregulation.

7. In an attempt to determine the effects of both chronic potassium (K) depletion and chronic heat exposure on the ability to affect the activity of sodium (Na) - potassium pumps (i.e. Na/K ATPase activity), we have modified an assay which provides a simple and rapid method for the determination of the number of Na-K pumps based on the number of H^3-ouabain binding sites. Adult male rats were divided into four treatment groups which consisted of a control group (standard diet, 23-25°C), K depleted group(K-free, Mg-supplemented diet, 23-25°C), heat-acclimated (28d) control group (standard diet, 33°C) and finally a K depleted, heat acclimated (28d) group (K-free, Mg-supplemented diet, 33°C). Following exposure to the treatment regimens various muscles and organs were excised for analysis. Specific displaceable H^3-ouabain binding sites in isolated tissue preparations have been shown to represent an equivalent number of Na-K pumps. In brief, the methodology consists of excising small tissue biopsies (2-14 mg) and transferring these to a Tris buffer (10 mM), H_3PO_4 (3mM), $MgSO_4$ (3mM), Tris vanadate (1 mM) and sucrose (250 mM). Following 2 washes the samples are transferred into a second incubation medium containing H^3-ouabain (1.8 nCi/ml) at 37°C in conical tubes for approximately 60 min.

Following the incubation with H^3-ouabain , all samples are washed in unlabeled buffer, blotted on dry filter paper, and weighed. Each biopsy is allowed to soak overnight in 1 ml TCA containing 0.1 mM unlabeled ouabain as carrier. After shaking, 0.5 ml is taken for scintillation counting of the H^3-activity. On the basis of the specific activity of the incubation media, the amount of H^3-activity retained in the biopsies following the wash is calculated after correction for non-specific retention and expressed as pmol per g weight. Thus, the quantitation of the total concentration of H^3-ouabain binding sites which reflect Na-K pumps will allow us to elucidate any cellular change that is occurring in response to dietary and environmental perturbations which ultimately impact organ function. Tissue count data are being quantified so that specific activity of ouabain uptake can be expressed as Na-K pumps per gram of tissue wet weight.

PUBLICATIONS:

1. Armstrong, L.E., R.W. Hubbard, E.W. Askew, and R.P. Francesconi. Responses of soldiers to 4-gram and 8-gram NaCl diets during 10 days of heat acclimation. In: Nutritional Needs in Hot Environments, B.M. Mariott (ed)., National Academy Press, Washington, D.C., pp. 247-258, 1993.

2. Armstrong, L.E., W.C. Curtis, R.W. Hubbard, R.P. Francesconi, R. Moore, and E.W. Askew. Symptomatic hyponatremia during prolonged exercise in the heat. Medicine and Science in Sports and Exercise, 25:(5), 543-549, 1993.

3. Armstrong, L.E., R.W. Hubbard, E.W. Askew, J.F. DeLuca, C. O'Brien, A. Pasqualicchio, and R.P. Francesconi. Responses to moderate and low sodium diets during exercise-heat acclimation. International Journal of Sport Nutrition, 3:207-221, 1993.

4. Francesconi, R.P., L.E. Armstrong, N.M. Leva, R.J. Moore, P.C. Szlyk, W.T. Matthew, W.C., Curtis, Jr., R.W. Hubbard, and E.W. Askew. Endocrinological responses to dietary salt restriction during heat acclimation. In:

Nutritional Needs in Hot Environments, B.M. Marriott (ed)., National Academy Press, Washington, D.C., pp. 259-275, 1993.

5. Francesconi, R.P., Endocrinological and metabolic response to acute and chronic heat exposures. In: Handbook of Physiology: Adaptation to the Environment. M.J. Fregly and C.L. Blatteis, editors, Oxford University Press, New York, NY, In press, 1993

6. Francesconi, R.P., N.M. Leva, C. Johnson, and R.W. Hubbard. Potassium deficiency in rats: Effects on rates of dehydration and electrolyte homeostasis. Journal of Thermal Biology, In press, 1993.

7. Gentile, B.J., C.R. Johnson, R.P. Francesconi, and R.W. Hubbard. Thermoregulatory effects of atropine in the cold using a hypotrichotic rat model. Proceedings of the Medical Defense Bioscience Review, U.S. Army Medical Research and Development Command, 2:575-584, 1993.

8. Sils, I.V., P.C. Szlyk, K.A. Tartarini, L.J. Hubbard, E. Glass, D.M. Caretti, and A.A. Darrigrand. Chronic implantation of non-occlusive catheters and flow probes in the splanchnic and hindlimb vasculature of the rabbit. Laboratory Animal Science, In press, 1993.

9. Szlyk, P.C., I.V. Sils, D.B. Caretti, R.J. Moore, L.E. Armstrong, K.A. Tartarini, R.P. Francesconi, E.W. Askew, and R.W. Hubbard. Orthostatic responses to dietary sodium chloride restriction during heat acclimation. Proceedings of the Space Operations, Applications, and Research Symposium (SOAR), In press, 1993.

ABSTRACTS:

10. Durkot, M.J., R.P. Francesconi, and L. DeGaravilla. Thermoregulatory and metabolic responses to an adenosine A1 antagonist during exercise in the heat. The FASEB Journal 7:A452, 1993.

11. Gentile, B.J., C. Johnson, R. Francesconi, and R. Hubbard. Thermoregulatory effects of atropine in the cold

using a hypotrichotic rat model. Medical Defense Bioscience Review, 2:575, 1993.

12. Sils, I.V., P.C. Szlyk, K.A. Tartarini, L. Hubbard, E. Glass, D.M. Caretti, and A.A. Darrigrand. Chronic implantation of non-occlusive catheters and flow probes in the splanchnic bed in the rabbit. The FASEB Journal 7:A780, 1993.

13. Szlyk, P.C., I.V. Sils, D.M. Caretti, R.J. Moore, L.E. Armstrong, K.A. Tartarini, R.P. Francesconi, E.W. Askew, and R.W. Hubbard. Orthostatic responses to dietary sodium chloride restriction during heat acclimation. Proceedings of the Space Operations, Applications & Research Symposium (SOARS), 1993.

14. Szlyk, P.C., I.V. Sils, K.A. Tartarini, and R.P. Francesconi. Regional differences in blood gases and flows in the splanchnic bed in the awake rabbit. The FASEB Journal 7:A780, 1993.

PRESENTATIONS:

15. Gaffin, S.L. Endotoxins in Stress and Exercise. Third Annual Meeting on Advances in the Diagnosis, Prevention & Treatment of Endotoxemia and Sepsis, Philadelphia, PA, 17-18 June 93.

16. Francesconi, R.P. Research Program in Comparative Physiology, WRAIR Fellows in Global Medicine, 27 September 1993.

17. Durkot, M.J. Nutritional Requirement for Exercise and Physical Conditioning in the Heat. Lecture in Clinical Exercise Physiology, Sargent College of Allied Health Professions, Boston University, 8 October 1993.

KEY BRIEFINGS:

18. Ralph P. Francesconi, Ph.D. Armed Services Biomedical Research Evaluation and Management Committee (ASBREM), USARIEM, Natick, MA, 26-27 January 1993.

19. Ralph P. Francesconi, Ph.D. Review & Analysis of our Research Programs to COL Schnakenberg, MAJ Leu, RA III; LTC Moore and MAJ Schimomora, RA V; COL Lake, MRDC Comptroller; and COL Tyner, MRDC Deputy Commander, USARIEM, Natick, MA, 11-12 February 1993.

20. Ralph P. Francesconi, Ph.D. Review & Analysis of RA III Research Programs to COL Robert Gifford, Director RA III, and MAJ Karl Friedl, Staff Officer RA III, USARIEM, Natick, MA, 27 October 1993.

SIGNIFICANT VISITORS:

Dr. Bellingham, Intern Program, Mt. Ida College, Newton, MA, 14 April 1993.

Dr. W.R. Beisel, FACP, Consultant, Bethesda, MD, 15 April 1993.

Dr. Ruth Lipman, Human Nutrition Research Center, USDA Tufts University Medical Center, Boston, July 1993.

Dr. W. Selvamurthy, Defense Institute of Physiology and Allied Sciences, Delhi, India, 22 September 1993.

SIGNIFICANT TDY:

Stephen L. Gaffin, Ph.D. Presented a talk entitled "Endotoxins in Stress and Exercise" sponsored by International Business Communications, Philadelphia, PA, 16-18 June 1993.

Brian J. Gentile, CPT, VC. Attended 1993 Medical Defense Bioscience Review, Baltimore, MD, 9-13 May 1993.

Brian J. Gentile, CPT, VC. Attended 130th Annual Meeting of the AVMA, Minneapolis, MN, 17-21 July 1993.

Patricia C. Szlyk, Ph.D. Science Fair Judge, 44th International Science and Engineering Fair (ISEF), Gulfport, MS, 9-14 May 1993.

Patricia C. Szlyk, Ph.D. Attended Space Technology Interdependency Group, Space Operations, Applications, and Research Symposium, NASA Johnson Space Center, Houston, TX, 2-5 August 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Francesconi, Ralph P., Ph.D., Division Chief. Proposal reviewer, Army Research Office. Advisor, NAS/NRC Research Associateship Program. Reviewer, Aviation Space & Environmental Medicine, American Journal of Physiology, Neurotoxicology and Teratology; Invited review chapter entitled "Endocrinological and Metabolic Response to Acute and Chronic Heat Exposure" for the Handbook of Physiology; Reviewer - DOD/VA Cooperative Research Program.

Durkot, Michael J., Ph.D., Research Physiologist. Reviewer, Aviation, Space & Environmental Medicine, Circulatory Shock, and Journal of Applied Physiology. Peer Review Panel, Breast Cancer Research Program, USAMRDC.

Gaffin, Stephen L., Ph.D., Research Physiologist. Reviewer, Perspectives in Exercise Science and Sports Medicine, Volume 6, 1993. Invited to write a major review on "Exercise, Heat, and Toxic Shock (endotoxemia)" for Medicine, Exercise, Nutrition and Health. Chapter prepared by invitation and submitted to the American Physiological Society "Limits of Tolerance to Heat" with J.R.S. Hales and R.W. Hubbard for the Handbook of Physiology. Invited to lecture at the International Conference on Endotoxins and Sepsis.

Szlyk-Modrow, Patricia C., Ph.D., Research Physiologist. Special Awards Judge, US Army Laboratory Command, International Science & Engineering Fair. Massachusetts State Science Fair Judge. Reviewer, Aviation, Space & Environmental Medicine and Journal of Applied Physiology, and Laboratory Animal Science.

CELLULAR PHYSIOLOGY & PATHOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Hyperthermic exposure is associated with impaired blood flow. This may be due, in part, to modulations in the synthesis of vasoactive metabolites by the endothelium. To evaluate the direct effects of heat on endothelial cell prostaglandin synthesis, porcine aortic endothelial cells were seeded ($1x10^5$ cells) into 24 well tissue culture plates and cultured for 7 days. The confluent cultures were then exposed to 37°C or 43°C for 15, 30, or 60 min. Following exposure, culture medium was collected for prostacyclin (PGI_2) and thromboxane (Tx) radioimmunoassay. Compared to 37°C, the mean 15, 30 and 60 min basal PGI_2 production at 43°C was significantly reduced (282.8±33.8 vs. 82.5±4.4 pg/μg of protein). In contrast, Tx basal metabolism at 37°C and 43°C were similar (15.0±2.0 vs. 13.4±1.9 pg/μg of protein). This resulted in a significant shift in the PGI_2 : Tx ratio from 18.9 : 1 at 37°C to 6.2 : 1 at 43°C. These findings illustrate the potential of hyperthermic exposure to directly reduce the PGI_2 : Tx ratio, which may contribute to heat-induced circulatory problems.

2. A variety of methods are employed in the heating and cooling of cells and tissues to mimic the conditions under which environmental extremes evoke cellular injury. These methods have included the use of temperature-controlled circulating water or forced air. Such methods have a limited capacity to accurately and easily reproduce heating and cooling exposures. These limitations were addressed through the use of new technology to electronically regulate temperature modulations. Thermoelectric modules (TEM) were affixed to a temperature dispersion plate upon which a culture flask was placed. The TEM is a miniature, solid state heat pump. A programmable thermoelectric cooler controller regulated the activity of the TEM to modulate the temperature of culture medium or whole blood contained within the culture flask. Replicate exposures of mild, moderate or extreme heat stress were conducted without significant differences. Such a method for

controlling environmental temperature permits replication of exposures with great ease, accuracy and precision.

3. Acute, subchronic and chronic exposures to cholinergic compounds may result in differing effects. The efficacy of pyridostigmine bromide (PY) prophylaxis against organophosphorus poisoning depends on post exposure atropine (AT) administration. AT induces a dose-dependent increase in rate of rise of core temperature in heat exposed humans and rats. To determine whether AT's anticholinergic potency is altered following PY administration, we examined AT's effects following acute or subchronic (2 weeks) PY administration in the sedentary heat-stressed rat. Four groups of rats were acutely (a, iv) treated with saline (SAL) or PY (100 ug/kg) followed by SAL or AT (200 ug/kg), and 4 groups were subchronically (c, osmotic pump) treated with SAL or PY (20 ug/hr) followed by SAL or AT (200 ug/kg). Fifteen minutes following the final injection, rats were subjected to an ambient temperature of 41.5°C until a core temperature of 42.6°C was attained. Heat tolerance times were significantly improved for cPY+SAL over aPY+SAL (241 ± 9 vs 187 ± 16 min, mean ± SE) and for cPY+AT over aPY+AT (76 ± 9 vs 57 ± 2 min). The improvement in thermoregulation resulted from increased salivary water for evaporative cooling indicated by % weight loss (corrected for fecal loss) during heat stress: cPY+SAL over aPY+SAL (8.4 ± 0.3 vs 6.6 ± 0.5 %). This increased heat tolerance resulting from subchronic anticholinesterase administration resembles changes seen with heat acclimation.

4. Reported that HSD (hypertonic (7.5%) saline in 6% dextran 70) was more efficacious than saline in the treatment of heat stroke with or without dehydration in rats. To examine the mechanism of this improvement, rats were deprived of water for 24 hr (DE) or not (ND), heat-stressed restrained (RE, to prevent saliva spread) or unrestrained (NR), and 4 ml/kg of saline (SAL) or HSD was administered at the end of heat stress (Tcore = 42.3°C). Blood samples for hematocrit and osmolality were taken at baseline (pre-24 hr dehydration), pre-heat, post-heat, and 30 min post-HSD or SAL. Percent change in plasma volume

(PV) from baseline was significantly decreased (-5.7±1 vs 3.7±1%) by DE vs ND, maintained through hyperthermia, and increased (13.1±2.3 vs -5.1±1.7%) by HSD vs SAL administration. Serum osmolality was increased (301±1 vs 297±1mOsmol/L) by DE vs ND, further increased and significantly different (308±1 and 317±1mOsmol/L) for RE and NR rats through hyperthermia, and increased (325±1 vs 313±1mOsmol/L) by HSD vs SAL. HSD treatment significantly increased PV following hyperthermic dehydration which contributed to increased radiant cooling and survival.

5. Artificial human skin (Skin^2, Advanced Tissue Sciences) provides a model for evaluating environmental effects on human skin cells in differentiated tissues without some of the confounding activities of cardiovascular function, blood cells, hormones and hepatic acute phase proteins. This approach tends to reduce our dependency on animal research while providing a response by human cells. The transition of findings to applications for the soldier should therefore be facilitated. Recent research indicates that skin may play a significant role in injury, repair and the inflammatory response. Our earlier research indicated that cold injury induced elevations in regulatory products from these cells such as cytokines (IL-1α) and prostaglandins (PGE_2). This research is designed to measure the effects of heat on IL-1α, TNF-α, K^+, prostaglandins (PGE_2 and TxB_2), nuclear matrix apparatus protein, immunohistochemical and immunogold localizations of IL-1α, and <u>in situ</u> hybridization of IL-1α mRNA. Although data collection for all groups continues, data available to date suggest that a 90 min exposure to 37° - 43°C does not alter mean values for release of PGE_2 (range, 406pg/0.1ml - 711pg/0.1ml), TxB_2 (38pg/0.1ml - 53pg/0.1ml) or IL-1α (3pg/0.1ml - 5pg/0.1ml, below the lower test limit of 10pg/0.1ml). Two additional temperatures (44° and 45°) must be evaluated; preliminary results on a small number of these two groups suggest a threshold for heat-induced release of PGE_2 and IL-1α at 44°C. Immuno-localization of IL-1α will be run on groups above the threshold. TNFα, K^+ and nuclear matrix apparatus protein release must also be evaluated. Scanning electron microscopy indicates that,

unlike "Living Skin Equivalent," "Skin²" has less clearly defined layers with the support membrane occupying a considerable portion of the volume. Completion of these groups is in progress.

PUBLICATIONS:

1. Bowers, W. Jr., M. Blaha, J. Sankovich, D. Patterson, and D. DuBose. Prostaglandin E_2, Interleukin-1α, and potassium release from artificial human skin after freeze-thaw injury. Cryobiology, 30:272-278, 1993.

2. DuBose, D.A. and R. Haugland. Comparisons of endothelial cell G- and F-actin distribution in situ and in vitro. Biotechnic & Histochemistry, 68:(1)8-16, 1993.

3. Haugland, R.P., W. You, V.B. Paragas, K.S. Wells, and D.A. DuBose. Simultaneous visualization of G- and F-actin in endothelial cells. Journal of Histochemistry and Cytochemistry, In press, 1993.

4. Matthew, C.B. Ambient temperature effects on thermoregulation and endurance in anticholinesterase-treated rats. Life Sciences, 52:1343-1349, 1993.

5. Matthew, C.B., J.F. Glenn, and W.D. Bowers, Jr. Acute vs subchronic pyridostigmine administration: Effects on the anticholinergic properties of atropine. Proceedings of the 1993 Medical Defense Bioscience Review, 2:605-614, Baltimore, MD, 1993.

6. Matthew, C.B., M.J. Durkot, and D.R. Patterson. Fluid shifts induced by the administration of 7.5% sodium chloride in 6% dextran 70 (HSD) in dehydrated swine. Circulatory Shock, 41:150-155, 1993.

ABSTRACTS:

7. Bowers, W., M. Blaha, J. Sankovich. Human cells in living skin equivalent (LSE) release prostaglandin E_2 (PGE_2) and interleukin-1α (IL-1α) after freeze thaw. Experimental Biology '93 (FASEB), New Orleans, 1993.

8. DuBose, D., J. Hinkle, D. Morehouse. Hyperthermic effects on bovine aortic endothelial cell (BAEC) permeability & cytoskeletal F-actin. Experimental Biology '93 (FASEB), New Orleans, LA, 1993.

9. Matthew, C.B., J.F. Glenn, W.D. Bowers. Acute vs. subchronic pyridostigmine administration: Effects on the anticholinergic properties of atropine. Medical Defense Bioscience Review, Baltimore, MD, 1993.

10. Matthew, C.B., M.J. Durkot, D. Patterson. Fluid shifts induced by 7.5% sodium chloride in 6% dextran 70 (HSD) in dehydrated swine. Experimental Biology '93 (FASEB), New Orleans, LA, 1993.

PRESENTATIONS:

11. Matthew, C.B. An animal model of cholinergic drug effects: thermoregulation and exercise performance. Invited seminar: University of Connecticut at Storrs, Biopsychology Department, 18 October 1993.

12. Matthew, C.B. An animal model to investigate heatstroke pathophysiology and exercise responses. Invited seminar: University of Connecticut at Storrs, Sports Medicine Department, 18 October 1993.

KEY BRIEFINGS:

13. Wilbert D. Bowers, Ph.D. Review & Analysis of our Research Programs to COL Schnakenberg, MAJ Leu, RA III; LTC Moore and MAJ Shimomora, RA V; COL Lake, MRDC Comptroller; and COL Tyner, MRDC Deputy Commander, USARIEM, 11-12 February 1993.

14. Wilbert D. Bowers, Ph.D. Review & Analysis of RA III Research Programs to COL Robert Gifford, Director RA III, and MAJ Karl Friedl, Staff Officer RA III, USARIEM, 27 October 1993.

15. Michael D. Blaha. Safety Overview Briefing to EP Staff, 17 September 1993.

SIGNIFICANT VISITORS:

LTC Michael P. Sarras, Jr., IMA, 7-18 June 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Bowers, Wilbert D., Ph.D., Branch Chief. Treasurer, New England Society for Electron Microscopy.

DuBose, David A., Ph.D. Research Microbiologist. Reviewer, Aviation, Space and Environmental Medicine, and American Physiological Society, Journal of Applied Physiology. Sigma Xi, Science Fair Judge Program.

Matthew, Candace B., MAT, Research Biologist. Reviewer, Aviation, Space and Environmental Medicine, and Life Sciences. Secretary, Sigma Xi.

ENVIRONMENTAL PHYSIOLOGY & MEDICINE DIRECTORATE

RESEARCH FINDINGS: EXECUTIVE SUMMARY

- Determined that acclimatization to 4,300 m was effective in reducing acute mountain sickness in soldiers re-exposed to this altitude after a 8-day stay at sea level. Improved tolerance was attributed to lower plasma volumes and increased oxygen saturation with reinduction versus initial exposure.

- Determined that the time course of high altitude deacclimatization is similar to that of acclimatization. Reductions in total body water and plasma volume from initial sea level values were still evident after an 8-day return to sea level.

- Established within a group of dismounted soldiers moving together over mountainous terrain that individual energy expenditure is proportional to total weight. This finding suggests new strategies for predicting the mission energy requirements of foot soldiers.

- Demonstrated that following altitude acclimatization and return to sea level for eight days, nearly 70% of the ventilatory acclimatization response was still present during reintroduction to altitude.

- Conducted and completed data acquisition on a study to determine the effects of autologous erythrocyte infusion prior to rapid deployment to high altitude on physical performance decrements and altitude-related illness.

- Initiated development of research study to examine the effect of the chemical protective ensemble on the performance of military tasks and associated physiologic responses following rapid deployment and subsequent staging to moderate and high mountain field environments.

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- Designed and conducted research protocol evaluating the effect of wearing the chemical protective overgarment with ballistic protective vest and load bearing equipment on soldier's ventilatory function, and physical and cognitive performance.

- Submitted a protocol to investigate if oral glycerol is successful in preventing and/or treating high altitude illness fluid compartment volumes and treatment with oral glycerol" was submitted.

- Determined that acute altitude exposure (4300 m) resulted in a 20% decrease in intraocular pressure, with a nadir after day two followed by a gradual increase toward sea-level values. It appears that altitude-induced intraocular pressures changes are relatively rapid and undergo an acclimatization phenomena.

- Developed a leg extension ergometer, limited to the quadriceps muscle, which will be used to quantify muscle fatigue during dynamic exercise under hypoxic conditions.

- Initiated a human study to determine if the impaired endurance performance of muscle during dynamic, submaximal exercise in acute hypobaric hypoxia is linked with an impaired ability to increase central neural activity and/or local muscle activation.

- Developed a modified Pitot tube sensor that measures the maximum wind velocity within a 100 degree arc rather than a 10 degree arc. This directional-insensitivity and low power requirement of this sensor makes it ideal for field applications.

- Computer modeling studies were completed for The Technical Cooperation Program (TTCP) key technical actions using data from copper manikin evaluation of various chemical protective (CP) garments from the United Kingdom, Canada, and the United States participating in TTCP.

- The experimental phase of a human evaluation study (addressing another specific TTCP key technical area) was completed on physiological responses and biophysical properties of chemical protective materials for the TTCP.

- In cooperation with the Army Research Laboratory, Battlefield Environment Directorate, White Sands Missile Range, New Mexico, a contract effort to implement the USARIEM Heat Strain Model in a prototype tactical weather information system was completed.

- Effects of the Aircrew Uniform Integrated Battlefield (AUIB) over a microclimate conditioning vest (MC) were studied using our thermal copper manikin. The AUIB with vest was first evaluated for thermal and vapor transmission properties.

- The USARIEM heat strain model was used to predict the amount of heat needed to be extracted (H_{req}) from aviators doing light work (170 W) and exposed to various cockpit temperatures (Tc) and humidities (%rh).

- The first use of ARIEM's new environmental chamber 024 was accomplished in a biophysical and human physiological evaluation of the prototype cold-wet glove systems.

- Final algorithm analyses of an extremity cold exposure model was completed.

- A cold shivering algorithm was developed and integrated into a PC interactive thermoregulatory model. The algorithm should prove useful in predicting shivering as a function of core temperature and skin temperature for a whole body cold air model capable of environments at -50°F

- Experimental testing was completed on several control samples of textile materials in accordance with the International Organization for Standardization (ISO)

7726 & 11092, *Instruments and methods for measuring physical quantities*.

- A collaborative study with U.S. Naval Health Center, San Diego, CA was initiated as a joint study involving a copper manikin and model validation of thorax and thigh microclimate cooling schemes.

- Prototype wet weather parkas, as part of a Soldier Enhancement Program (SEP), were evaluated in a climatic chamber at three different wind speeds.

- Model prediction analyses of endurance times were completed in a study to down- select garments from 11 prototype Advanced Battle Dress Overgarments. Following the manikin and modeling results from a down-selection process, the experimental phase of a human physiological study was achieved.

- A design concept based on an expert system prototype was completed that is applicable and should become quite useful as a comprehensive environmental and physiology workstation for military health care planners and researchers in both operational and training settings.

- Developed and validated a microcomputer-controlled system to measure skin (limb) blood flow by strain gauge plethysmography.

- Conducted a field study to determine whether drinking carbohydrate-electrolyte solutions rather than water would improve performance during military relevant tasks.

- Conducted a field study to determine the effectiveness of backpack mounted, liquid cooled, microclimate cooling systems to reduce the heat stress of troops undertaking MOS specific duties while wearing chemical protective clothing.

- Initiated a climatic chamber study examining the interaction between dehydration level and exercise

intensity on thermoregulatory responses and exercise-heat stress performance.

- Initiated a climatic chamber study to quantify heat exchange in women when wearing chemical protective (CP) clothing during physical work in the heat.

- Continued an epidemiological study of heat injury among Marine recruits. Thus far, data have been collected and organized on ≈2400 cases of exertional heat injury occurring at the Parris Island MCRD from 1979 to 1993.

- Summarized our research on the effects of anticholinergic therapy (atropine sulfate, 2 mg) on dry and evaporative heat exchange during exercise - stress.

- Conducted a climatic chamber study to examine thermoregulatory and renal responses to glycerol hyperhydration in soldiers exposed to cold air.

- Conducted a climatic chamber study to determine if glycerol hyperhydration might exacerbate the pressor responses to cold air exposure.

PUBLICATIONS:

1. Pandolf, K.B. Importance of Environmental Factors for Exercise Testing and Exercise Prescription. In: Exercise Testing and Exercise Prescription for Special Cases-Theoretical Basis and Clinical Application. 2nd Edition, J.S. Skinner (Ed.). Lea & Febiger, Philadelphia, PA, pp. 87-109, 1993.

2. Pandolf, K.B., L.A. Stroschein, R.R. Gonzalez and M.N. Sawka. Prediction Modeling of Physiological Responses and Human Performance in the Heat with Application to Space Operations. In: Seventh Annual Workshop on Space Operations, Applications and Research (SOAR '93). NASA Lyndon B. Johnson Space Center, Houston, TX. (In Press), 1993.

3. Pandolf, K.B. Heat Tolerance and Aging. Experimental Aging Research, 20: (In Press), 1993.

4. Pandolf, K.B. and A.J. Young. Altitude and Cold; The Cardiac Patient. In: Heart Disease and Rehabilitation. 3rd Edition, M.L. Pollock and D.H. Schmidt (Eds.). Human Kinetics Publishers, Inc., Champaign, IL. (In Press), 1993.

5. Pandolf, K.B. Exercise in the Heat and Avoiding the Heat Disorders. In: Current Therapy in Sports Medicine. 3rd Edition, J.S. Torg and R.J. Shephard (Eds.). Moseby-Year Book, Inc., Philadelphia, PA. (In Press), 1993.

ABSTRACTS:

6. Pandolf, K.B. Influence of Chronic Physical Activity on Thermoregulatory Adaptations of the Middle-Aged and Elderly During Heat Stress. Paper delivered at Symposium entitled, Human Adaptations to the Environmental Extremes of Cold and Heat, Proceedings of The III World Congress of the International Society for Adaptive Medicine, Tokyo, Japan, April 1993.

7. Pandolf, K.B., B.J. Freund, A.J. Young, J.M. McKay, D.E. Roberts and M.N. Sawka. Effects of Adiposity on the Thermal, Cardiovascular and Fluid Responses to Cold Exposure. Medicine and Science in Sports and Exercise, 25: S62, 1993.

8. Pandolf, K.B., L.A. Stroschein, R.R. Gonzalez and M.N. Sawka. Prediction Modeling of Physiological Responses and Human Performance in the Heat with Special Application to Space Operations. Space Operations, Applications, and Research Symposium, NASA Johnson Space Center, Houston, TX, August 1993.

PRESENTATIONS:

9. Pandolf, K.B. U.S. Army Terrestrial Altitude, Cold Stress and Heat Stress Research, Tri-Service Program Briefing before the Armed Services Biomedical Research Evaluation and Management Committee, U.S. Army Research

Institute of Environmental Medicine, Natick, MA, 26-27 January 1993.

10. Pandolf, K.B. Influence of Chronic Physical Activity on Thermoregulatory Adaptations of the Middle-Aged and Elderly During Heat Stress, Seminar before the Department of Physiology, School of Medicine, University of Occupational and Environmental Health, Kitakyushu, Japan, 23 April 1993.

11. Pandolf, K.B. Environmental Extremes Research Program, Tri-Service Program Briefing before the Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee, U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Frederick, MD, 26-27 August 1993.

12. Pandolf, K.B. Human Performance at the Environmental Extremes of Heat, Cold and High Altitude, Sports Biology Colloquium, Springfield College, Springfield, Massachusetts, 23 September 1993.

13. Pandolf, K.B. Can You Enhance the Capacity for Human Exercise Performance in the Heat? 1993 Southeast American College of Sports Medicine Scholar Lecture Tour at the University of Georgia, Georgia State University, Auburn University, Florida State University, and the University of Florida, October 1993.

14. Pandolf, K.B. Exercise in Adverse Environments: Heat, Cold and Altitude, Lecture in Clinical Exercise Physiology, Sargent College of Allied Health Professions, Boston University, Boston, MA, 29 November 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Pandolf, Kent B., Ph.D., Research Director. Adjunct Professor of Health Sciences, Department of Health Sciences, Sargent College of Allied Health Professions, Boston University, Boston, MA; Adjunct Clinical Professor of Sports Biology, Springfield College, Springfield, MA; Vice-President and Board of Directors, International Society for Adaptive Medicine, Freiburg, Germany.

Chairman, Publications Committee, American College of Sports Medicine. Counselor, Steering Committee, Environmental and Exercise Physiology Section, The American Physiological Society; Editorial Board Member, Exercise and Sport Sciences Reviews, Medicine and Science in Sports and Exercise. Reviewer, Medicine and Science in Sports and Exercise; Journal of Applied Physiology; Perceptual and Motor Skills; Journal of Cardiac Rehabilitation; European Journal of Applied Physiology and Occupational Physiology; Aviation, Space and Environmental Medicine; American Industrial Hygiene Association Journal.

ALTITUDE PHYSIOLOGY AND MEDICINE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. A study was conducted to determine whether reductions in total body water and plasma volume are a primary component of high-altitude acclimatization. Phenomena describing deacclimatization to high-altitude is scanty and not well understood, and research in this area could characterize the responses of personnel deployed to altitude, removed, and then redeployed. We hypothesized that deacclimatization, like high-altitude acclimatization, is a gradual process, and that the reduced hydration status during high-altitude exposure would persist after a return to sea level. Ten male Special Operations soldiers underwent a 10-day sea level phase, a 16-day acclimatization phase at Pikes Peak, CO (4,300 m), and an 8-day deacclimatization phase at sea level. Total body water was measured by deuterium dilution and percent change in plasma volume was calculated using hematocrit and hemoglobin concentration at sea level, after 1,2, and 13 days at Pikes Peak, and after 1 and 6 days of deacclimatization. Total body water and plasma volume were decreased within one day at altitude, were further reduced with chronic exposure, and remained decreased for 6 days after return to sea level. These results demonstrate that high-altitude acclimatization, in terms of body hydration

status, is retained for at least 6 days after return to sea level and suggest that high-altitude acclimatization and deacclimatization may follow a similar time course. Therefore, individuals with prior acclimatization may have a increased capacity to tolerate high-altitude environments upon redeployment and have the potential to have increased levels of mental and physical performance, productivity, and overall health.

2. The capability to accurately predict the energy demands of operations in mountainous terrain is needed to ensure realistic mission planning. A new strategy for predicting the mission energy requirements of foot soldiers was identified through a systematic energy balance study of a Special Operations (SOF) A-team during a mid-winter climb of Mt. Rainier. Total daily energy expenditure (TDEE) was measured by the doubly labeled water (DLW, $^{2}H_{2}{}^{18}O$) method in six soldiers over six days that included five days of strenuous winter exercise at 2500 to 3100 m elevation. Use of body energy stores (-9.54 ± 1.54 MJ/d or -2280 ± 368 kcal/d; $\bar{X}$ ± SD) was estimated from changes in body weight, body density (hydrodensitometry), and total body water ($H_{2}{}^{18}O$ dilution). The subjects wore computerized activity monitors and kept daily records of ration consumption (9.87 ± 3.60 MJ/d or 2359 ± 860 kcal/d). Activity patterns, as well as the calculated number of hours of activity per day, were very similar among subjects. The DLW TDEE was closely correlated with total weight (DLW TDEE = 0.193 × total weight - 2.048; r^2 = 0.95). Differences in total soldier weight (body weight + load) accounting for 95% of the variance in TDEE. In soldiers engaged in similar load-bearing activities, the rate of metabolic energy expenditure is primarily determined by the cost of supporting body weight. These findings suggest new models that would use total body weight, speed of movement, and grade and substrate inputs, to predict the energy costs for moving over mountainous terrain.

3. Following two weeks of acclimatization to altitude, plasma lactate accumulation decreases and the contribution of fat to fuel metabolism increases during exercise. We hypothesized that these adaptations would persist upon

reintroduction to altitude (RA) after eight days at sea level (SL). Six male lowlanders ($\bar{X}$±SD; 31±5 yrs, 83±10 kg, 57±5 $ml \cdot kg^{-1} \cdot min^{-1}$ $\dot{V}O_{2peak}$) progressively exercised to exhaustion at the same relative percentage of $\dot{V}O_{2peak}$ at SL, on acute exposure to altitude (AA), after 16 days residence at 4300 m on Pikes Peak (PP), and during a 24-h RA. Pre- and immediately post-exercise blood samples were analyzed for lactate (LAC), glycerol (GLY), free fatty acid (FFA), and glucose (GLU) concentrations. Respiratory exchange ratio (RER) was measured at 75% $\dot{V}O_{2peak}$ after 40 min of exercise. Pre-exercise LAC did not differ across all conditions (Range:1.0-1.1 $mM \cdot L^{-1}$). Post-exercise LAC for PP (3.3±1.0) and RA (3.3±1.4) were 30% lower than SL (4.7±0.9;$P<0.05$) and 50% lower than AA (6.6±2.3;$P<0.05$). There were no significant differences either pre- or post-exercise across the four conditions for GLY, FFA, and GLU. RER decreased ($P<0.05$) from SL (0.95±0.03) to PP (0.90±0.04) and upon RA (0.89±0.04). With acclimatization to altitude, (1) exercise plasma lactate accumulation is decreased, (2) absolute fat lipolysis remains unchanged, and (3) the fractional contribution of fat to fuel metabolism increases. These adaptations in substrate utilization are retained nearly 100% upon reintroduction to altitude even after eight days at sea level.

4. Laboratory studies have shown that submaximal endurance exercise capacity, and possibly the gross efficiency of exercise (total power output/total metabolic energy expenditure), increase after altitude acclimatization. To test the hypothesis that similar changes would be evident in the field, eight males (age = 29±3 y ($\bar{X}$±SD), wt = 85.4±12.8 kg) were studied during two competitive ascents of Pikes Peak (1875 to 4300 m) via the 22 km Barr Trail, one before and one after 10 days of acclimatization to 4300 m. Total power output in kJ = the product of total subject weight in Newtons and the 2425 m change in elevation. Oxygen uptake ($\dot{V}o_2$, $L \cdot min^{-1}$), calculated from minute-to-minute heart rate (HR) monitor records and the relationship of submaximal $\dot{V}o_2$ to HR determined before and after acclimatization, was used to calculate metabolic energy expenditure. Pre- vs. post-acclimatization values were: $\dot{V}o_2$ = 2.69±0.47 vs. 2.62±0.31

$L \cdot min^{-1}$ ($P>0.05$); finishing time = 288±38 vs. 247±35 min ($P<0.05$); gross efficiency = 13.4±1.7 vs 15.2±1.6 % ($P<0.05$). These data are consistent with reports that acclimatization to high altitude improves submaximal endurance exercise performance and increases the gross efficiency of exercise.

5. A study was conducted to investigate the potential of autologous erythrocyte infusion ("blood doping") to enhance physical capacity and avert hypoxia-induced performance decrements in unacclimatized soldiers rapidly transported to high altitude. Sixteen fit men were divided into two groups: the Reinfusion Group and the Placebo Group. The groups were matched for aerobic fitness, body composition and age. The Reinfusion Group (n=8) had a unit of whole blood removed and the erythrocytes stored for subsequent reinfusion on two occasions at 5 week intervals; the Placebo Group (n=8) was to have completed this procedure also, however, operational requirements of the subjects' parent unit precluded this. All subjects had their maximal oxygen uptake and 2-mile run time determined. Physiological responses to prolonged exercise, respiratory control, blood volume, body water balance, altitude-illness symptomatology measurements were also assessed over a 15-day period at sea level (USARIEM, Natick, MA). After completing the sea-level baseline tests, the Reinfusion Group was intravenously infused with the autologous erythrocytes which had been stored; the Placebo Group received an equivalent volume of saline, intravenously infused. Approximately 12 hours later, the subjects' blood volume was measured, and then the men traveled rapidly to Pikes Peak, CO (4300 meters). The entire battery of tests was repeated during the 1st through the fourth day at high altitude, and again on the 10th through the 15th day at altitude. The subjects were then rapidly returned to Natick where blood volume and maximal oxygen uptake were determined a final time. Laboratory analyses of blood samples and statistical evaluation of the data are continuing at present.

6. A study conducted to examine the effect of the NBC overgarment (Protective Clothing, PC) and CB mask in

combination with body armor (BA) and Load Bearing Equipment (LBE) on the pattern and mechanics of breathing and cognitive performance during rest and sustained aerobic exercise (~600 W). The specific objectives were to assess the effect of the NBC ensemble on: 1) ventilatory capacities; 2) respiratory system elastance; 3) pattern of breathing during rest and sustained moderate intensity exercise; 4) verbal tasks and exercise ventilation, and; 5) cognitive performance and subjective reactions. Fifteen test volunteers were studied. Data collection was started in April 1993 and concluded in October 1993. Studies were performed on two uniform combinations: MOPP 0+M40 CB mask modified for minimal inspiratory resistance (empty C2 filter canister) and MOPP 1+M40 CB mask with standard C2 filter canister. Additionally, over the MOPP 1 uniform the volunteers wore BA (fragmentation protective vest) and LBE (pistol belt with suspenders) configured with a fighting load minus a weapon. Preliminary analysis indicates that: 1)the PC+BA+LBE decreased Maximal Breathing Capacity by ~5%; 2) the combination of PC+BA+LBE and the CB mask decreased Maximal Breathing Capacity by~25%; 3) the PC+BA+LBE significantly decreased lung volume, and had negligible effect on maximal flows; 4) the PC+BA+LBE increased respiratory system elastance (stiffness) by ~16%, whereas the CB mask increased respiratory system resistance by ~75%, and; 5) a sustained speaking task hinders the soldier's ability to maintain adequate exercise ventilation and may promote development of adverse respiratory sensations and contribute to becoming a MOPP-induced casualty. The impact of these findings on exercise ventilation have not yet been analyzed. However, preliminary review of our exercise data suggests that the pattern of exercise breathing was more influenced by the elastic forces opposing breathing rather than the resistive forces, even though the PC+BA+LBE constituted a smaller impairment on the respiratory system than the CB mask.

7. Initiated development of a study to examine the effect of the chemical protective ensemble on the performance of military tasks and associated physiologic responses following rapid deployment and subsequent staging to moderate (~6,000 ft) and high (~10,000 and 14,000 ft) mountain field environments. The specific objectives will

be to assess the interaction of moderate and high terrestrial elevations and wear of the chemical protective ensemble on: 1) physical work performance of selected military tasks; 2) the associated responses of the ventilatory and cardiovascular systems, and; 3) perception of exertion and respiratory sensations. The contribution of a staged or gradual ascent on amelioration of the high-altitude induced performance decrements following rapid deployment from sea level will also be assessed.

8. A study was approved and currently underway to determine whether fluctuations in hormones during the two phases of the human menstrual cycle are associated with differences in work performance during acute exposure to hypobaric hypoxia due to their effect on ventilation. None of the research previously conducted on work performance in women at altitude has controlled for the effect of the menstrual cycle. The study is a cross-over repeated measures study design with each eumenorrheic and ovulatory volunteer completing one maximal and one submaximal exercise test during the follicular phase (days 4-7) and luteal phase (6-9 days after LH surge) of their menstrual cycle at both sea level and high altitude for a total of four maximal and four submaximal exercise tests. Since women currently comprise approximately 11% of the US Army and could be deployed to areas where high altitude may affect their ability to complete their mission successfully, the data obtained in this study would be extremely valuable to the US Army.

9. Exposure to high altitude induces a multitude of physiological changes attempting to compensate for the hypoxia. Circulatory changes such as plasma volume and stroke volume losses and increases in heart rate and blood pressure are well documented. It is not known, however, if interfering with these apparently normal acclimatization indexes would affect responsiveness to a circulatory challenge. In a recent investigation of the effects of autologous erythrocyte infusion in sea-level residents rapidly transported to high altitude, the opportunity was presented to study if responsiveness would be altered by increasing blood volume. Sixteen Special Operation Forces soldiers served as test subjects. On the day prior to

being transported to the summit of Pikes Peak, CO. (4300 m), eight soldiers (experimental group) received two units of autologous erythrocytes suspended in NaCL-glucose while the other eight soldiers (placebo group) received 700 ml of NaCl-glucose only. Tilt-table tests were conducted on both groups prior to the infusions at sea level and on the first, third, and twelfth day of residence at altitude. Tilt-table tests consisted of 20 minutes of supine rest followed by 15 minutes of 60 degree upright tilt. Blood pressure, cardiac output, and indexes of myocardial contractility (via impedance cardiography) were assessed every five minutes in each position. Preliminary data analyzes indicate that despite significant physiological alterations such as increases in blood volume and oxygen carrying capacity (based on results of companion studies), blood pressure, cardiac output and myocardial contractility did not differ significantly between the placebo and experimental groups. These results suggest that an increase in blood volume does not alter the normal cardiovascular changes in response to a passive circulatory challenge.

10. An experimental device was developed which totally isolates the quadriceps muscle during dynamic leg extension exercise. The device allows a subject to periodically provide a maximal voluntary contraction during the conduct of submaximal, dynamic exercise of any power output so that the rate of fatigue of the quadriceps can be quantitated. The primary attribute of this exercise model is that local muscle fatigue can be studied without the confounding effect of a central circulatory limitation. The device is currently being used for the study of muscle fatigue and muscle endurance in hypobaric hypoxia (see below).

11. There is a paucity of information describing how voluntary muscle strength and endurance during submaximal exercise is affected by altitude exposure. Therefore, an investigation was recently initiated to determine if the impaired endurance performance of muscle during dynamic, submaximal exercise in acute hypobaric hypoxia (4300 m) is linked with an impaired ability to increase central neural activity and muscle activation or an impairment confined within the muscle. Our approach is to utilize our newly-

developed leg-extension device and monitor the rate of fatigue (via periodic determinations of maximal voluntary contractions) and determine temporal relationships between gradual muscle contractile failure and electromyograph activity in normoxia and hypobaric hypoxia. Also monitored throughout exercise will be cardiac output, blood pressure, ratings of perceived exertion, and oxygen consumption. To date, data collection on four subjects (of 8 to 10) have been completed. Preliminary analyzes indicate that maximal oxygen consumption is only 5% to 10% reduced rather than 25%-28% reduced as reported for 2-legged cycling or running at the same altitude and that submaximal exercise is little altered. These results are consistent with cardiac output being the primary factor in limiting performance during activities involving large groups of muscle in hypoxia.

PUBLICATIONS:

1. Malconian, M.K., P.B. Rock, J.T. Reeves, A. Cymerman, and C.S. Houston. Operation Everest II: gas tensions in expired air and arterial blood at extreme altitude. Aviation Space and Environmental Medicine 64: 37-42, 1993.

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ABSTRACTS:

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8. Boushel, R., C.S. Fulco, T. Lyons, S.F. Lewis, and A. Cymerman. Forearm blood flow at rest and during leg exercise before, during and after exposure to altitude (4300 m). FASEB Journal 7:A448, 1993.

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PRESENTATIONS:

18. Cymerman, A. Introduction to hypobaric medicine: Historical perspectives and general physiological aspects. Boston University, Sargent College of Allied Health Professions, Boston, MA, November 1993.

19. Hoyt, R.W. Human energy balance in extreme environments. Sargent College of Allied Health Professions, Boston University, February 1993.

20. Muza, S.R. Medical problems at high altitude. Temple University School of Medicine, Clinical Conference, Philadelphia, PA, October 1993.

21. Muza, S.R. Mechanisms of altitude-induced pulmonary hypertension. Temple University School of Medicine, Pulmonary Grand Rounds, Philadelphia, PA, October 1993.

22. Muza, S.R. Pulmonary limitations to exercise at high altitude. Boston University, Sargent College of Allied Health Professions, Boston, MA, November 1993.

23. Muza, S.R. Pulmonary circulation in health and disease. Boston University, Sargent College of Allied Health Professions, Boston, MA, December 1993.

24. Rock, P.B. Medical problems of high terrestrial altitude. Naval Undersea Medical Institute, Naval Submarine Base New London, Groton, CT, March 1993.

25. Rock, P.B. Medical problems of high terrestrial altitude. U.S. Army School of Aviation Medicine, Ft. Rucker, AL, March 1993.

26. Rock, P.B. Problems in high mountain environments, Flight Surgeons Basic Course, Army School of Aviation Medicine, Ft. Rucker, AL, August 1993.

KEY BRIEFINGS:

27. James A. Devine. Hypoxia at high terrestrial altitudes and in altitude simulators. Desk Guide on Medical Criteria and Standards for Health Hazard Assessment of Material Systems. Aberdeen Proving Ground, MD, December 1993.

28. Reed W. Hoyt, Ph.D. Health Hazard Assessment of Hypoxia. U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, MD, April, 1993.

SIGNIFICANT TDY:

Allen Cymerman, Ph.D. Co-investigator in a research project, Effects of autologous erythrocyte infusion in sea-level residents rapidly transported to high altitude, Colorado Springs, CO, July 1993.

Reed W. Hoyt, Ph.D. Health Hazard Assessment Meetings, U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, MD, April, 1993.

Timothy P. Lyons, Ph.D., CPT, MS. Co-investigator in a research project, Effects of autologous erythrocyte infusion in sea-level residents rapidly transported to high altitude, Colorado Springs, CO, July 1993.

Stephen R. Muza, Ph.D., MAJ, USAR. Individual Mobilization Augmentee, USAARL, Fort Rucker, AL, March, 1993.

Stephen R. Muza, Ph.D., Co-investigator in a research project, Effects of autologous erythrocyte infusion in sea-level residents rapidly transported to high altitude, Colorado Springs, CO, July 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Allen Cymerman, Ph.D., Division Chief. Editorial Board Wilderness Medical Society; Adjunct Associate Professor, Sargent College of Allied Health Professions, Department of Health Sciences, Boston, MA. Reviewer for the Journal of Applied Physiology, American Journal of Applied Physiology; Journal of Wilderness Medicine; Aviation Space and Environmental Medicine.

Charles S. Fulco, M.A.T. Member American College of Sports Medicine and American Physiological Society. Reviewer, Aviation, Space and Environmental Medicine.

Reed W. Hoyt, Ph.D. Secretary and Program Advisory Committee representative for the Hypoxia Interest Group of the American Physiologic Society; Hypoxia Group representative to the APS Exercise and Environmental Physiology Section steering committee. Member, USARIEM Scientific Review Committee. Formal invitation and acceptance as a Co-investigator on the SLS-3 Space Shuttle experiment Measurement of Energy expenditure during spaceflight using the doubly labeled water technique.

Stephen R. Muza, Ph.D. Member, American Physiological Society, American Thoracic Society, American College of Sports Medicine, Sigma XI, President Natick Chapter Sigma Xi. Reviewer, Journal of Applied Physiology; Chest, Medicine & Science in Sports and Exercise; American Journal of Respiratory and Critical Care Medicine.

Timothy P. Lyons, CPT, MS, Ph.D. Member, American College of Sports Medicine and American Physiological Society. Guest Lecturer, Boston University, Sargent College of Health Sciences. Reviewer, Aviation, Space, and Environmental Medicine.

James M. Roach, M.D., MAJ, MC. Member, American College of Physicians, American College of Chest Physicians, American Thoracic Society, and American Medical Association. Board certification in Internal Medicine and Pulmonary Disease and a Diplomat of the National Board of Medical Examiners. Commonwealth of Massachusetts Medical license.

Paul B. Rock, D.O., Ph.D., LTC, MC. Diplomat in Internal Medicine. Member of American College of Physicians, American Federation for Clinical Research, American Association for the Advancement of Science, Aerospace Medical Association, Association of Military Surgeons of the U.S., and Society of U.S. Army Flight Surgeons. Medical licensure in Colorado and Massachusetts. Reviewer, Journal of Applied Physiology; Aviation, Space and Environmental Medicine.

BIOPHYSICS & BIOMEDICAL MODELING DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Computer modeling studies were completed for The Technical Cooperation Program (TTCP) key technical actions. Using the key focuses from last year's data on the copper manikin evaluation of various chemical protective (CP) garments from the United Kingdom, Canada, and the United States participating in TTCP, specific heat strain modeling results were completed this year. The modeling thrusts covered responses to various environments and work rates. Output parameters were estimates of work to rest cycles and water requirements possible in various warm environments during assorted work activities. Heat strain was determined by estimation of maximum endurance times

based upon output using the USARIEM Heat Strain model. The biophysical analyses of the countries' clothing coefficients were first integrated into the current USARIEM Heat Strain Model which are now present in the database. The model outputs incorporated 3 wind speeds and a time analysis signifying light, moderate, and heavy casualty categories based on rectal temperatures reaching set limits of 39°C, 39.5°C, and 40.0°C, respectively. The U.S. Army standard 90-mil, Woodland, chemical protective overgarment (BDO) worn with Battle Dress Fatigues (BDU) underneath, (in MOPP IV configuration), served as the reference garment in the analyses. Relative rankings of endurance times were established for a worst case environmental scenario (T_a=120 °F/ 20% rh and 1 m/s wind) based on *light* casualty in troops during *light* work intensities (metabolic levels ranging from 172 to 325 watts). These metabolic heat productions are equivalent to a walk on hard terrain at $1 m \cdot s^{-1}$ with no load, or a pace as high as a walk with a 30 kg backpack, respectively. Garment configurations using the UK chemical protective garment incorporating the Mark IV worn with underwear, or worn with the US BDU , and Canadian Threat Oriented Protective Posture (TOPP) configurations provided the highest overall endurance times of 10 chemical protective garment configurations evaluated (71, 65, 64 min, respectively, $P \leq 0.04$ among rankings). It is suggested further research options focus on the relative effectiveness of using a wettable synthetic material or hydrophilic covers bonded to a CP garment and hood (or the upper torso).

2. The experimental phase of a human evaluation study (addressing another specific TTCP key technical area) was completed on physiological responses and biophysical properties of chemical protective materials for the TTCP. All participating countries completed experiments in their laboratories on their respective current issue CP ensembles in an agreed standard protocol. The TTCP standard environmental protocol decided upon by a consensus of TTCP nations was Climate: Ta= 35 C, 50 %RH; Globe temp= Ta; windspeed = 2.5 mph. Physiological responses on male subjects, acclimated to heat, were studied during exercise at 3.5 mph on a treadmill ($\dot{V}O_2$ of about 1 ℓ/min). Exercise

time is to continued until the subjects reach a threshold rectal temperature limit of 39°C. During CY 93, ARIEM completed experiments on the current issue BDO and the AirForce ground crew CP uniform. Following data reduction and consolidation of results from all participant's experimental data set, modeling will begin using actual experimental data matched against 3 different heat strain models. This latter effort will be initiated 3rd Qtr FY94.

3. In cooperation with the Army Research Laboratory, Battlefield Environment Directorate, White Sands Missile Range, New Mexico, a contract effort to implement the USARIEM Heat Strain Model in a prototype tactical weather information system has been completed. This prototype system uses archived weather data and provides soldier system oriented Intelligence Preparation of the Battlefield (IPB)products as color coded map overlays for heat injury risk, drinking water needs, maximum safe work time, and optimal work/rest cycle limits over a corps/brigade sized region. Work is in progress to complete links to real time and forecast weather data from Army resources.

4. Heat strain in helicopter pilots is a persistent problem often leading to hypohydration and prolonged fatigue in crewmen. Part of the difficulty affecting endurance times in pilots is because ventilated air in cockpits is not cooled and the cockpit absorbs large amounts of solar radiation further increasing heat stress. During CY93, effects of the Aircrew Uniform Integrated Battlefield (AUIB) over a microclimate conditioning vest (MC) were studied using our thermal copper manikin. The AUIB with vest was first evaluated for thermal and vapor transmission properties. The USARIEM heat strain model was then used to predict the amount of heat needed to be extracted (H_{req}) from aviators doing light work (170 W) and exposed to various cockpit temperatures (Tc) and humidities (%rh). H_{req} at specific combinations of Tc and %rh was depicted in terms of watts per total body cooling (W). Cockpit black globe temperature (Tg) was computed as a 20 °F offset of Tc and used in WBGT. Over a wide range of cockpit and globe temperatures and humidities, successful modeling was possible to assess the amount of body cooling

(in watts) necessary to keep aviators below a threshold of probable heat strain. A theoretical cooling extraction rate (W) was quantified from model output as the magnitude of heat needed to be removed from the body, not the amount delivered by an MC system. The modeling results showed that it is critical that the efficiency of each delivery system be pre-calculated to ensure that necessary cooling is feasible since the amount of heat a MC vest is able to extract from a human is not always known. Modeling of extraction rates serves as a key option to aid in such calculations.

5. In CY93, the first use of ARIEM's Environmental Chamber 024 was accomplished in a biophysical and human physiological evaluation of the prototype cold-wet glove systems. Biophysical evaluations were conducted of the intermediate cold-wet glove at 0°C and -18°C. A Statement of Need - Clothing and Individual Equipment (SN-CIE) was written in JAN 1992 by the U.S. Army Natick Research, Development & Engineering Center (NATICK), the U.S. Army Infantry School (USAIS), the U.S. Army Test and Evaluation Command (USATECOM), and the U.S. Army Infantry Board (USAIB) for a Preplanned Product Improvement (P^3I) of the Interim Men's and Women's Intermediate Cold-Wet Glove (ICWG). The SN-CIE states that the P^3I ICWG is required to provide environmental protection better than the Interim ICWG to a properly clothed sedentary soldier in temperatures down to -17.8°C (0°F) for an extended period of time. Four (4) hours protection without supplemental heating is desired. Additionally, the glove outer shell will be waterproof to the extent that the insulative quality is not significantly degraded. It is desired that water does not penetrate through the glove to the hand. Eight human volunteers dressed in a complete Extended Cold Weather Clothing Ensemble evaluated the test handwear during 4 hour sedentary exposures in ARIEM 024 cold chamber at 0°C (gloves wetted) and -17.8°C (gloves dry). Mean skin, rectal, and finger temperatures were continuously recorded. None of the test gloves could meet the SN-CIE requirement of 4 hours protection at - 17.8 °C. A few volunteers were able to endure 4 hours at 0°C with externally-wetted gloves while wearing the Interim (control) and three of the

prototype gloves. All of these gloves employed a Gore-Tex membrane and advanced polyester insulation.

6. Final algorithm analyses of an extremity cold exposure model was completed. A lumped parameter model of a finger tip (the anatomical site with most susceptibility to cold injury) was developed. A successful analytical solution to the effects of cold induced vasodilation (CIVD) was completed in which the critical phenomenon is simulated by a series of symmetrical triangular wave patterns depicting the behavior of finger skin blood flow upon exposure to cold.

7. In CY93 a cold shivering algorithm was developed and integrated into a PC interactive thermoregulatory model. The algorithm should prove useful in predicting shivering as a function of core temperature and skin temperature for a whole body cold air model capable of environments at -50 °F. This multiple linear regression equation was developed that combines core temperatures and skin temperature response in the control of shivering derived from a database of USARIEM cold-air and cold-water immersion experiments. The algorithm was initially written into a six-node thermoregulatory model predicting metabolic and other physiological responses to cold stress at various combinations of work and clothing systems. The yet untested model tracks shivering responses as a function of core and skin temperature level during transients (e.g. rapid air temperature drops) and steady-state response (e.g.long term constant cold environments).

8. Experimental testing was completed on several control samples of textile materials in accordance with the International Organization for Standardization (ISO) 7726 & 11092, *Instruments and methods for measuring physical quantities*. Determination of these baseline values during the initial stages of protective clothing design will facilitate the selection of new materials which will provide a greater degree of thermal comfort when compared to existing materials. The Soldier Survivability Directorate, U.S. Army Natick Research, Development and Engineering Center and the Materials Research Branch, U.S.

Navy Natick Clothing and Textile Research Facility also have been contracted by Program Manager, Clothing and Individual Equipment to evaluate four similar configurations on their respective Skin Models. This initial testing was a screening process to identify differences, if any, in the testing methods and results among the three laboratories. Results demonstrated that the equipment and testing methods employed at the three research facilities produced comparable test values, when normalized on a common air motion, on the four sample materials.

9. A collaborative study with U.S. Naval Health Center, San Diego, CA was initiated as a joint study involving a copper manikin and model validation of thorax and thigh microclimate cooling schemes. The initial data will come from previously conducted human research protocol done by a contractor for the Naval Health Research Center. USARIEM will develop algorithms based on the current heat strain model to determine maximum cooling extraction rates possible in a segmented manikin employing specific evaluations of the cooling system. This CY, a copper manikin, originally acquired through the U.S. Air Force, Brooks Air Force Base was completely refurbished by Biophysics & Biomedical Modeling Staff. The manikin has modern computer controls and is divided into 6 thermally isolated zones so that it has the capability of 10 individual control circuits. This manikin will allow maintaining uniform surface heating temperature patterns. Programming of the manikin zones is underway so the manikin can be totally computer controlled and incorporated with a state-of-the-art Hewlett-Packard data acquisition system in its final design.

10. Prototype wet weather parkas, as part of a Soldier Enhancement Program (SEP), were evaluated in a climatic chamber at three different wind speeds. The ambient conditions were maintained at 70°F and 50% rh and the copper manikin was used to measure the insulation (Clo) and the vapor permeability (im) of the ensembles. The garments evaluated this C include: a) Standard Parka-double coated polyurethane on nylon; b) Standard Parka with Field Coat

Liner; c) SEP Parka-single back-coated polyurethane on nylon; d)SEP Parka with Field Coat Liner; e) Standard Field Coat; f) Standard Field Coat with Liner; and g) the extended cold weather clothing system (ECWCS) Parka. Prediction modeling was then done to compare thermoregulatory responses of the candidates to the control at various metabolic intensities at 68°F. The substitution of a rainwear system which is operationally equivalent to that in the present ECWCS rainwear system would allow the SEP program to advance in finding additional cost-effective materials. The results of the tests also are applicable to USARIEM's efforts in cold stress modeling program.

11. Prediction analyses of endurance times were completed in a study to down- select garments from 11 prototype Advanced Battle Dress Overgarments. Four selected items were then to be studied in more detail by human experimental trials. Using a copper manikin database, model prediction analysis was first carried out with the USARIEM Heat Strain Model. The Advanced Battle Dress Overgarment program will probably transition into the JSLIST effort. USARIEM's clothing database and modeling results of the ABDO will allow ready access of modeling information to prevent reduplication of effort. Heat strain was determined by estimation of maximum endurance times based upon output using a current version of the USARIEM Heat Strain model. This CY, biophysical analyses of ABDO prototypes' clothing coefficients were first integrated into the current USARIEM Heat Strain Model. The model outputs incorporated 3 wind speeds and a time analysis signifying light, moderate, and heavy casualty categories based on rectal temperatures reaching set limits of 39°C, 39.5°C, and 40.0°C, respectively. The U.S. Army standard 90-mil, Woodland, chemical protective overgarment (BDO) worn alone (e.g. no Battle Dress Fatigues (BDU) underneath (but otherwise in MOPP 4 configuration) served as the reference garment in comparing the prototypes. Overall, the use of liners employing VonBlücher technology in the ABDO candidates provided higher evaporative potential (i_m/Clo) than the 50 mil foam liners under all, but two, circumstances during evaluation of the outer shells. The exception to this trend was evident,

initially, by the rankings of i_m/Clo evaluations of a Repel shell and prototypes employing the 50 mil foam liner. These prototypes displayed a slightly higher evaporative potential at high wind speeds. At low and high wind speeds, use of the VonBlücher liner with Repel shells displayed a higher evaporative potential than the Repel shell used with 50 mil foam liner. Based on heat transfer characteristics evaluated on a copper manikin, and compared to values of chemical protective garments which are currently type classified and in the system, the ten prototypes evaluated did not predict reduced heat strain any more efficaciously than wearing the current Woodland BDO in warm-humid to hot- dry environments at moderate work intensities (M= 425 watts). Modeling results indicated that ABDO prototypes with VonBlücher liners along with the lower weight NyCo liners offer important possibilities for development of a chemical protective ensemble useful in temperate and moderate thermal environments, provided convective heat exchange is enhanced by wind speeds > 4 m/s (≈ 9 mph).

12. Following the manikin and modeling results from item 11 addressed above, this C the experimental phase of a human physiological study was achieved. The study will provide data on the actual physiological responses of volunteer subjects to heat stress while wearing the down-selected prototype Advanced Battledress Overgarments (ABDO). The prototype and control BDO overgarments are described as follows:

Ensemble	Shell	Liner
BDO	4.5 oz NYCO twill	superactivated carbon foam, 60 mil
P1S	4.5 oz NYCO twill	saratoga carbon spheres, 180 $g \cdot m^{-2}$
P2S	6.0 oz NYCO ripstop	Saratoga carbon spheres, 180 $g \cdot m^{-2}$

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P2F	6.0 oz NYCO ripstop	superactivated carbon foam, 60 mil
S3	ECWCS/Gore-tex©	Saratoga carbon spheres, 180 $g \cdot m^{-2}$

The study was initiated with 13 subjects (8 USMC reservists and 5 US Army volunteers). After 6 days of acclimation, garment testing began with 12 volunteers. The test environment for the first five days was 86°F, 50% rh and 2.5 mph wind speed. Subjects wore the overgarments over underwear in MOPP-4 configuration with chemical protective (CP) mask, gloves and overboots. Ten volunteers began the second test week, which consisted of five days of testing at 100°F with a 6.5 mph wind speed. Primary test results consisted of three types of data; total walking time ("endurance"), change in rectal temperature (ΔT_{re}) or body core temperature (ΔT_b), and water loss data (the "efficiency" or ratio of sweat to evaporative water loss). Endurance: At 86°F, the walking endurance time was significantly less for the BDO relative to both Saratoga garments (P1S and P2S). Walking time was significantly greater at 100°F for the lighter Saratoga (P1S) than foam (P2F), BDO or PTFE (S3) and subjects walked significantly longer while wearing the heavier Saratoga (P2S) than PTFE (S3). Rectal and body temperature changes: In the 86°F environment, because the rate of increase in $\Delta T_{re} \cdot h^{-1}$ and $\Delta T_b \cdot h^{-1}$ were smaller, both Saratoga (P1S and P2S) overgarments were significantly better than the BDO overgarment. Other differences in the 86°F environment were not significant. In the 100°F environment, the rate of increase in mean body temperature ($\Delta T_b \cdot h^{-1}$) for the PTFE (S3) and BDO overgarments were significantly higher than either Saratoga garment (P1S or P2S). The rate of increase for the foam liner garment (P2F) was significantly higher than the rate of increase for the lighter weight Saratoga garment (P1S). At 100°F, the rate of increase in rectal temperature ($\Delta T_{re} \cdot h^{-1}$) for PTFE (S3) was significantly higher than the rate for either Saratoga or the foam garments (P1S, P2S or P2F) and the BDO rate of increase was significantly higher than the rate for the lighter Saratoga

garment (P1S). Sweating efficiency: At 100°F, the efficiency of sweating was greater for the lighter Saratoga (P1S) than foam (P2F), the BDO or PTFE (S3) and the efficiency was greater for the heavier Saratoga (P2S) than PTFE (S3). There were no significant differences in the 86°F environment. The results of this study were consonant with the modeling evaluations previously discussed. The subjects' physiological strain, compared to responses with the standard BDO, were also less severe while wearing overgarments with the 4.5 Oz NYCO with the Saratoga (Von Blücher) lining or the 6 Oz NYCO with Saratoga (Von Blücher) lining prototypes.

13. A design concept based on an expert system prototype was completed that is applicable and should become quite useful as a comprehensive environmental and physiology workstation for military health care planners and researchers in both operational and training settings. The workstation integrates various predictive models including the USARIEM Heat Strain Model, cold, and high altitude modalities. Overlying the actual computation of output from various thermal, nutritional, and military input decision, are various menus for support information. These include access to the various USARIEM environmental field manuals and technical notes.

PUBLICATIONS:

1. Chang, S.KW. and R.R. Gonzalez. Air velocity profiles around the human body. ASHRAE Transactions, 99(1):450-458, 1993.

2. Chang, S.KW. Electric field induced volume and membrane ionic permeability changes of red blood cells. IEEE Transactions on Biomedical Engineering, 40(10):1054-1059, October, 1993.

3. Chang, S.KW. The effect of electric field on sickled red blood cells. In: Proceedings of the 15th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 15(3):1492-1493, 1993.

4. Chang S.KW. The effect of frequency on electric field induced surface force in red blood cell membrane. In: Proceedings of the 1993 IEEE Nineteenth Annual Northeast Bioengineering Conference, pp. 86-87, 1993.

5. Gonzalez, R.R., C.A. Levell, L.A. Stroschein, J.A. Gonzalez and K.B. Pandolf. Copper manikin and heat strain model evaluations of chemical protective ensembles for The Technical Cooperation Program (TTCP). Technical Report T94-4, U.S. Army Research Institute of Environmental Medicine, Natick, MA, November 1993.

6. Matthew, W.T., L.A. Stroschein, L.A. Blanchard and J. Gonzalez. Technical testing of a prototype heat stress monitor: Software verification and laboratory evaluations of sensor performance. Technical Report T9-93, U.S. Army Research Institute of Environmental Medicine, Natick, MA, June 1993.

7. Matthew, W.T., R.E. McNally, G.B. McWilliams, S.F. Kirby, and H.D. Pfeiffer. Integration of a Heat Strain Prediction Model with Army Weather Data Resources. In: Proceedings of the 1993 Battlefield Atmospherics Conference, Las Cruces, New Mexico, 1993.

8. Reardon, M.J. Design concepts for an integrated environmental medicine workstation for prediction, simulation, and training. Technical Note TN 94-1, U.S. Army Research Institute of Environmental Medicine, Natick, MA, July 1993.

9. Santee, W.R., L.A. Blanchard, S.KW. Chang and R.R. Gonzalez, 1993. Biophysical model for handwear insulation testing. Technical Report T7/93, US Army Research Institute of Environmental Medicine, Natick, MA.

10. Santee, W.R. and W.T. Matthew, 1993. USARIEM studies soldiers' heat strain. US Army Research, Development and Acquisition Bulletin (May-June):54-55.

11. Shitzer, A., L.A. Stroschein, R.R. Gonzalez and K.B. Pandolf. Lumped parameter finger tip model exhibiting cold induced vasodilatation. In: Advances in Bioheat and Mass

Transfer Microscale Analysis of Thermal Injury Processes Instrumentation Modeling Clinical Applications, HTD-Vol. 268, Book No. H00879. R.B. Roemer (Ed.) New York, New York: The American Society of Mechanical Engineers, 1993, pp. 61-67.

PRESENTATIONS:

12. Chang, S.KW. The effect of electric field on sickled red blood cells. 15th Annual International Conference - IEEE
Engineering in Medicine and Biology Society, San Diego, CA, October 1993.

13. Chang S.KW. The effect of frequency on electric field induced surface force in red blood cell membrane. The 19th Annual Northeast Bioengineering Conference, Newark, NJ, March 1993.

14. Chang, S.KW. Air velocity profiles around the human body. ASHRAE Winter Meeting, Chicago, IL, January 1993.

15. Gonzalez, R.R. Thermoregulatory Models for Assessing the Thermal Environment, University of North Texas, Computer Sciences Department Seminar, Denton, TX, March 1993.

16. Gonzalez, R.R. Biophysics and Biomedical Modeling Division Review and Analysis Presentation, Natick, MA, 11 February 1993.

17. Gonzalez, R.R. Modeling and Biophysics. Presentation of Biophysics and Biomedical Modeling research and structure for Canadian Liaison members, Natick, MA, May 1993.

18. Gonzalez, R.R. Procedure for thermal analysis and modeling results of TTCP CP clothing systems, The Technical Cooperation Program (TTCP), Melbourne, Australia, 5 July 1993.

19. Gonzalez, R.R. Directorate Review and Research Studies. Department of the Army Technical Sciences Group, Natick, MA, 15 July 1993.

20. Gonzalez, R.R. Modeling heat exchange characteristics of long term space operations: role of skin wettedness and exercise, NASA SOAR Conference, 3-5 August 1993.

KEY BRIEFINGS:

21. Richard R. Gonzalez, Ph.D.. Modeling techniques for The Advanced Battledress Program, Natick, MA, 14 January 1993.

22. Richard R. Gonzalez, Ph.D. To The Technical Cooperation Program Meeting (UTP-6, Physiology and Performance Characteristics), Melbourne, Australia 4-9 July 1993.

SIGNIFICANT TDY:

William R. Santee, Ph.D. To carry out COR duties on SBIR contract for a heat stress device to Veritay Technology, Inc., Amherst, NY, 22 July 1993.

William R. Santee, Ph.D. To attend the NATO RSG 20/Panel 8 meeting, Kongsvoll, Norway, August 1993.

Clement A. Levell. To attend/participate in a microclimate JWG at Midwest Research Institute, Kansas City, MO, 1 July 93.

William T. Matthew. To attend the Integrated Unit Simulation System (IUSS) software introduction and training meeting, Simulation Technologies Inc. (STI), Dayton, Ohio, 4-5 February 1993.

William T. Matthew. To attend a preliminary coordination meeting for USARIEM Heat Strain Model implementation within the ARL, Battlefield Environment Directorate's "Terrain and Weather IPB Software Toolkit (TWIST)". Computing Research Laboratory, New Mexico State University, Las Cruces, New Mexico, 19-22 April 1993.

William T. Matthew. To attend training course on "UNIX Network Programming," Technology Exchange Company, Arlington Virginia, 14-18 June 1993.

William T. Matthew. To attend an in progress coordination meeting for USARIEM Heat Strain Model implementation within the ARL, Battlefield Environment Directorate's "Terrain and Weather IPB Software Toolkit (TWIST)". Battlefield Environment Directorate, White Sands Missile Range, New Mexico, 12-14 July 1993.

William T. Matthew. To collaborate on a Technology Base Executive Steering Committee (TBESC) Soldier System Modeling Working Group Meeting, Institute for Defense Analysis (IDA), Alexandria, Virginia, 16 November 1993.

William T. Matthew. To attend a ARL/Army Battlefield Atmospherics Conference, Las Cruces, New Mexico, 29 November-2 December 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Gonzalez, Richard R., Ph.D., Division Chief. Fellow, American Society of Heating, Refrigeration, Air-conditioning Engineers (ASHRAE). Doctoral Dissertation Committee, Dept of Computer and Mathematics, Memphis State University, Memphis, TN; 1993-present; Technical Consultant and Pre-Doctoral Student Advisor: University of North Texas, Computer Sciences Department. Advisor, National Academy of Sciences/National Research Council Research Associateship Program. Member, U.S. Army Joint Service Lightweight Integrated Suit Technology (JSLIST) Materials Evaluation Working Group. Member, NATO Research Study Group (RSG) 20, Panel VIII, "Modeling in Cold Environments", Brussels, Belgium.Intersociety Representative to the International Standards Organization (ISO) Technical Committee 59 "Ergonomics". Federation of American Societies for Experimental Biologists (FASEB), Washington, D.C., Minority Schools Lecturer Roster. American Society of Heating, Refrigeration, Air-conditioning Engineers, Advisory Board, U.S. Standards Committee on Indoor Thermal Occupancy (55-81R); Technical Consultant, Thermodynamics and Psychrometrics Committee (TC

1.1); Physiology and the Human Environment Committee (TC 2.1). Guest Reviewer: Science, American Journal of Physiology: Modeling in Physiology;Journal of Applied Physiology;J.Thermal Biology; American Society of Heating Refrigeration Engineers; Aviation, Space, and Environmental Medicine.

Matthew, William T. Member, Integrated Logistical Support Management Team for Army Environmental Heat Stress Monitor; Member Soldier System Architecture Working Group. USARIEM representative, Technical Base Executive Steering Committee (TBESC) Soldier System Modeling Working Group. Participant, Technical training program for Terrascan satellite data/image processing software package.

Chang, Stephan KW., Ph.D. Guest Reviewer, IEEE Transactions on Biomedical Engineering; Aviation Space and Environmental Medicine.

Santee, William R. Ph.D. Reviewer: NATO grant proposals; American Society for Testing and Materials. USARIEM Contract Officer Representative, Heat Stress Monitor, Phase I and II.

Endrusick, Thomas L. USARIEM member of Joint Service Lightweight Integrated Suit Technology (JSLIST) Materials Evaluation Working Group.

THERMAL PHYSIOLOGY & MEDICINE DIVISION

SIGNIFICANT RESEARCH FINDINGS/ACCOMPLISHMENTS:

1. This effort developed a microcomputer-controlled system which measures limb blood flow by strain gauge plethysmo-graphy. Hardware components include a microcomputer, data acquisition unit, Hokanson EC-4 plethysmography, pneumatic cuff inflation system, and a relay/switching unit for remote calibration of the plethysmography unit and inflation of the pneumatic cuffs. Software was developed for use with this system which

enables automatic electronic calibration of the plethysmography prior to each measure of limb blood flow, collection and storage of limb volume records at user-specified time intervals, interpretation of limb volume records, and calculation of rates of limb blood flow. To validate this system, forearm blood flows estimated using the automated system were compared with forearm blood flows estimated using a conventional (Whitney) hardware configuration that uses millivolt strip chart recordings. Correlations were done between blood flows measured in the right arm (automated system with 12-second distal occlusion) with blood flows estimated in the left arm (manual system with prolonged distal occlusion). It was concluded from these studies that the automated system was an valid alternative to manual collection systems. Interpretation of limb volume records and the use of 12 second periods of distal occlusion were sufficient for stable records of limb blood flow.

2. The purpose of this study was to examine whether drinking carbohydrate-electrolyte solutions rather than water during field training would improve performance during military relevant tasks. Using a cross-sectional design, twenty seven soldiers ingested either a 7% carbohydrate-electrolyte solution, a non-caloric non-electrolyte placebo solution, or tap water during three days of field training. Each drink was available *ad libitum*. Food intake was restricted to 2600 kcal per day. Physical training consisted of daily 10-13 mile road marches with rucksack, 2 h of rock climbing tasks and marksmanship training. Physical performance was evaluated before and during the third day of training with a timed rock climb, foot race, and marksmanship test. Mood perception were examined using the Perception of Mood State (POMS) questionnaire. In addition, blood samples were obtained before, during and after the 3 days of field training to examine body water status and immune function. Statistical analysis of the data is in progress.

3. Conducted a field study at the Aberdeen Proving Grounds in collaboration with the Edgewood Research Development and Engineering Center. The study was designed to measure the effectiveness of backpack mounted, liquid

cooled, microclimate cooling systems to reduce the heat stress of troops undertaking MOS specific duties in the field while wearing chemical protective clothing. The study utilized 10 volunteers in a Litter Patient Decontamination scenario, 8 volunteers in a Tech Escort scenario involving the clean up of leaking ordnance and 4 volunteers in a Forward Arming and Refueling Point scenario. Core temperature from an ingested radio transmitter, skin temperature, and heart rate were collected on all volunteers using the WRAIR Field telemetry system. Additionally, inlet and outlet temperatures of the coolant provided to the cooling vests were measured on a portable datalogger. Also, flow rate data provided by the cooling systems was collected, and rectal core temperatures as well as skin temperatures, and heart rates were collected on the dataloggers from those subjects who volunteered. Data analysis is currently underway.

4. This ongoing study examines the interaction of hydration level and exercise intensity on thermoregulatory responses to exercise-heat stress. The study consists of nine experimental trials during which subjects exercise for 50 min in a warm environment (30°C db, 50% rh). During each trial, subjects exercise at one of three exercise intensities (25%, 45% and 65% maximal oxygen uptake) at one of three levels of hydration (0%, -3% and -6% of body weight induced by prior exercise-fluid restriction). Esophageal, rectal and skin temperature, local sweat rate and cardiac output are measured during exercise. Blood samples are obtained to measure blood volume, osmolality, sodium concentration, and fluid regulatory hormone concentrations. Nine subjects have completed the protocol. Experimental testing will be complete in January 1994.

5. This ongoing study quantifies heat exchange in women when wearing chemical protective (CP) clothing. The wearing of CP clothing during physical work is potentially the most severe heat stress to which soldiers are exposed. In these experiments at T_a = 30°C and T_{dp} = 11°C (early follicular phase of the menstrual cycle), mean exercise (250-275 $W \cdot m^{-2}$) time for five women dressed in CP clothing (Clo = 2.1) was 52±13 min. In almost all cases, exercise

was terminated due to Institute safety procedures relating to sustained high heart rate. The conditions of this study imposed uncompensable heat stress. During exercise net heat flow averaged 206 $W \cdot m^{-2}$, the change in body temperature was 0.026 $°C \cdot min^{-1}$, evaporative heat loss through the clothing averaged 166 $W \cdot m^{-2}$, which was 44% of the sweating rate. Women exercising during uncompensable heat stress during the follicular phase of their menstrual cycles experienced slightly lower heat strain than that predicted by some thermoregulatory models. These women exercised for a similar duration as that predicted for men by the USARIEM Heat Strain model. This protocol is in the initial phase of an experimental design evaluating differences in performance in women during three distinct phases of the menstrual cycle. Tolerance times for women exercising while wearing chemical protective clothing are currently being determined for other phases (other than early follicular) of the menstrual cycle.

6. This ongoing study examines the epidemiology of heat injury. Thus far, the following data have been collected and organized: clinical data on ~2400 cases of exertional heat injury (EHI) at Parris Island MCRD 1979-1993, with laboratory data since 1986; available incident reports through 1993; data on the total population at risk, from Marine and DOD databases; hourly weather data; data for individual risk factors (e.g., training evaluation cards) for cases and matched controls; data on past and current recruit training schedules; and a list of all admissions to Beaufort Naval Hospital. Most of the foregoing data have been entered into a computerized complex relational database constructed for this project. The approach involves statistical analysis of the data to test multiple hypotheses, some of which are new and have arisen during examination and analysis of the data; and examination of the data to look for patterns and relationships not necessarily suggested by previously formulated hypotheses. Accomplishments to date include the following findings: Case rates of EHI were strongly related to the maximum WBGT the day before, independent of WBGT at the time of injury, suggesting a role for some cumulative effect of recent exercise-heat stress in the pathogenesis of EHI. Slow PFT

run times and high percent body fat each independently increased the individual risk of EHI over three fold. The conventional diagnostic criterion of rectal temperature ≥105°F for heat stroke is not a good index of neurological involvement in EHI patients, indicating that decisions about clinical management should give due weight to all indices of severity, without undue reliance on peak body temperature. Exertional heat stroke is a major risk factor for serious exercise-related cardiac arrhythmia unexplained by preexisting heart disease. (Exertional heat stroke hitherto has been reported to cause life-threatening arrhythmias only after cardiac injury from major complications.)

7. The effects of anticholinergic therapy, in this case intramuscular atropine sulfate (2 mg), on dry (sensible) and wet (insensible) heat loss (or gain) was studied in 22 healthy young men in a series of studies. Their average (±SD) age was 21±3 yr; mass, 77.9±8.6 kg; surface area, 1.98±0.12 m^2, height, 1.80±0.07 cm; body fat, 15.0±3.7%, and maximal aerobic power, 3.79±0.38 $L \cdot min^{-1}$. Experiments were done across a range of environmental conditions with dry bulb temperatures from 22 to 48° and dew point temperatures from 7 to 24°C. Exercise intensity ranged from 30 to 55% of the measured maximal aerobic power. The expected decrease in evaporative heat loss from the skin (E_{sk}) after atropine administration occurred in all environmental and exercise combinations and averaged -50%. This decrease in sweat secretion and evaporation due to antimuscarinic blockage at the sweat glands, decreased calculated whole body skin wettedness (w) from -46 to -69%. In contrast to the effect seen on insensible or wet heat loss, radiative and convective heat loss (sensible heat flux) increased after atropine treatment in all conditions studies. This increase ranged from 20 to 100%, which was 20-40 $W \cdot m^{-2}$ depending on the specific conditions of the individual equipment. In these studies, the systemic dose of atropine was sufficient to block cholinergic sweat gland activity and, we would be expected, core and skin temperatures were higher after atropine compared to control experiments. Reports of enhanced cutaneous vasodilation, whether

measured directly or calculated from the heat balance, were confirmed by these studies.

8. Cold exposure can reduce total body water, impairing exercise performance and increasing susceptibility to peripheral cold injury. Studies in both temperate and hot environments indicate glycerol is an effective hyperhydrating agent. One study reported glycerol was ineffective in blunting the diuresis associated with cold water immersion. No study has determined glycerol's effectiveness for hyperhydration during cold air exposure. This study examined thermoregulatory and renal responses to hyperhydration in seven men exposed to cold air (4 hr at 15°C, 30% rh) while seated and wearing shorts. Subjects completed separate, double-blind and counterbalanced trials including: a water only trial (37ml water·L total body water^{-1} (H_2O); and a water plus glycerol trial (37ml water·L total body water^{-1} plus 1.5 g glycerol·L total body water^{-1} (GLY). Diet, hydration, and rest were standardized prior to each trial. Thermoregulatory responses to cold were similar for each trial. Urine flow rates were higher during H_2O than during GLY (peak 11.8±0.6 vs 5.0±0.7 ml·min^{-1} $p<0.01$) which resulted in greater fluid retention during GLY (35.3±5.7 vs 18.2±4.3 percent $p<0.01$). Differences in urine flow rate and fluid retention were the result of a greater free water clearance during the H_2O trial ($p<0.01$). Plasma osmolality was reduced during H_2O (from 283±1 to a nadir of 278±2 mosm·kg^{-1} $p<0.05$), but increased during GLY (from 284±3 to a peak of 290±3 mosm·kg^{-1} $p<0.05$) due to an increased plasma glycerol concentration ($p<0.01$). These data indicate glycerol can be an effective hyperhydrating agent during cold air exposure.

9. Previously, we reported glycerol was an effective hyperhydration agent during exposure to both temperate and cold environments. We hypothesized that the expansion of total body water induced by glycerol hyperhydration might exacerbate the pressor responses to cold air exposure. Therefore, seven men exposed to cold air (4 hr at 15°C, 30%rh) completed separate, double-blind and randomized trials including: a water only trial (37 ml water·L total body water^{-1} (H_2O); and a water plus glycerol trial (37ml

water·L total body water^{-1} plus 1.5 g glycerol·L total body water^{-1} (GLY). Diet and hydration were standardized prior to each trial. As expected, metabolic rate increased during cold exposure (Pre 103±3, Peak 150±7 watts, $p<0.05$). Despite an increase in total body water, plasma volume decreased during cold exposure (Peak -8.1±1.2%, $p<0.05$) while arterial blood pressure increased (Pre 88±2, Peak 93±2 mmHg, $p<0.05$). Neither total peripheral resistance nor cardiac output were significantly effected by cold exposure. Stroke volume increased during cold exposure (Pre 69±6, Peak 87±4 ml·beat $p\leq0.05$) while heart rate fell (Pre 63±2, Nadir 58±2, $p<0.05$). While GLY increased fluid retention over H_2O (35±6 vs 18±4%, $p<0.01$), the above responses to cold exposure were similar between trials. These data indicate hyperhydration with glycerol has no apparent adverse effects on the pressor responses to resting cold exposure.

PUBLICATIONS:

1. Blewett, W.K., G.A. Ramos, D.P. Redmond, B.S. Cadarette, G.A. Hudgens, L.T. Fatkin, K. McKiernan. P^2NBC^2 Test: The effects of microclimate cooling on tactical performance. Technical Report, (In Press), December 1993.

2. Cadarette, B.S., M.D. Quigley, J.M. McKay, M.A. Kolka and M.N. Sawka. A physiological evaluation of the Soldier Integrated Protective Ensemble (SIPE) clothing system. USARIEM Technical Report T3-93, February 1993.

3. Coyle, E.F. and S.J. Montain. Thermal and cardiovascular responses to fluid replacement during exercise. In: Perspectives in Exercise Science and Sports Medicine, Vol. 6: Exercise, Heat and Thermoregulation. Eds. C.V. Gisolfi and D.R. Lamb, Indianapolis: Benchmark Press, pp. 179-213, 1993.

4. Doherty, T.J., L.A. Stephenson, M.A. Kolka, G.A. Sexton and R.R. Gonzalez. Automated strain gauge plethysmograph. USARIEM Technical Report T13-93, May 1993.

5. Freund, B.J., C. O'Brien and A.J. Young. Alcohol ingestion and temperature regulation during cold exposure: A brief review. Journal of Wilderness Medicine, (In Press), 1993.

6. Kolka, M.A. Heat acclimation. In: Intermittent High Intensity Exercise. Eds. D.A.D. Maclead et. al. (Eds.), London; Chapman and Hall, Proceedings of Rugby World Cup and Sports Medicine Congress, pp. 391-401, 1993.

7. Kolka, M.A. and L.A. Stephenson. Anticholinesterase administration during acute altitude exposure. Journal of Thermal Biology, 18: 103-112, 1993.

8. Kolka, M.A., M.D. Quigley, L.A. Blanchard, D.A. Taylor and L.S. Stephenson. Validation of temperature telemetry system during moderate and strenuous exercise. Journal of Thermal Biology, 18:203-210, 1993.

9. Kolka, M.A., L.A. Stephenson and R.R. Gonzalez. Sensible heat loss after systemic anticholinergic treatment. Proceedings of the International Congress of Physiological Sciences (Symposium on Temperature Regulation), Aberdeen, Scotland, Basel: Birkhauser, (In Press), 1993.

10. Levine, L., M.D. Quigley, W.A. Latzka, B.S. Cadarette and M.A. Kolka. Thermal strain in soldiers wearing chemical protective undergarment. USARIEM Technical Report T2-93, January 1993.

11. Sawka, M.N., R.R. Gonzalez and K.B. Pandolf. "Hydration and Blood Volume Effects on Human Thermoregulation in the Heat: Space Applications." Symposium on Space Operations, Applications and Research Proceedings. Houston, TX: NASA Johnson Space Center, (In Press), 1993.

12. Sawka, M.N., C.B. Wenger and K.B. Pandolf. Review: Human Responses to Exercise-Heat Stress. Technical Report No. T94/3, U.S. Army Research Institute of Environmental Medicine, Natick, MA, December, 1993.

13. Sawka, M.N., C.B. Wenger, A.J. Young and K.B. Pandolf. "Physiological Responses to Exercise in the Heat." In: Nutritional Needs in Hot Environments. B.A. Marriott, Ed., Washington, DC: Institute of Medicine, National Academy of Sciences Press, 54-73, 1993.

14. Sawka, M.N., C.B. Wenger and K.B. Pandolf. Thermoregu-latory Responses to Acute Exercise-Heat Stress and Heat Acclimation. Handbook of Physiology: Adaptation to the Environment. Washington, DC: American Physiological Society, Section 5, Chapter 10, (In Press), 1993.

15. Stephenson, L.A. and M.A. Kolka. Thermoregulation in Women. In: Exercise and Sport Sciences Reviews. Vol. 21, J. Holloszy (Ed.), Baltimore: Williams & Wilkins, pp. 231-262, 1993.

16. Wenger, C.B., M.D. Quigley and M.A. Kolka. 7-day pyridostigmine administration and thermoregulation during rest and exercise in dry heat. Aviation, Space and Environmental Medicine 64:905-11, 1993.

17. Wenger, C.B. The regulation of body temperature. In: Medical Physiology. R.A. Rhoades and G.A. Tanner (Eds.), Boston, MA:Little, Brown, In Press, 1993.

18. Young, A.J., M.N. Sawka, M.D. Quigley, B.S. Cadarette, P.D. Neufer, R.C. Dennis and C.R. Valeri. Role of thermal factors on aerobic capacity improvements with endurance training. Journal of Applied Physiology, 75:49-54, 1993.

ABSTRACTS:

19. Cadarette, B.S., M.D. Quigley, J.M. McKay, M.A. Kolka and M.N. Sawka. Thermal Strain of Wearing Soldier Integrated Protective Ensemble (SIPE) Clothing. Aviation Space and Environmental Medicine. 64:433, 1993.

20. De Luca, J.P., B.J. Freund, S.J. Montain, W.A. Latzka and M.N. Sawka. Hormonal Responses to Hyperhydration with Glycerol vs Water Alone. Medicine and Science in Sports and Exercise, 25:S36, 1993.

21. Freund, B.J., S.J. Montain, J.M. McKay, J.E. Laird and M.N. Sawka. Renal Responses to Hyperhydration Using Glycerol vs Water Alone Provides Insight to the Mechanism for Glycerol's Effectiveness. Medicine and Science in Sports and Exercise, 25:S35, 1993.

22. Hesslink, R.J., B.J. Freund, and T.E. Jones. Regulation of Thyroid Hormones in the Cold. Aviation, Space and Environmental Medicine, 64: 432, 1993.

23. O'Brien, C., B.J. Freund, R.L. Hesslink, J. McKay, T.E. Jones and A.J. Young. Indices of Dehydration in the Cold: A Field Study. Medicine and Science in Sports and Exercise, 25: S37, 1993.

24. Sawka, M.N., B.J. Freund, D.E. Roberts, C. O'Brien, R.C. Dennis and C.R. Valeri. Total Body Water, Extracellular Fluid and Plasma Responses to Hyperhydration with Aqueous Glycerol. Medicine and Science in Sports and Exercise, 25:S35, 1993.

25. Sawka, M.N., R.R. Gonzalez and K.B. Pandolf. Hydration and Blood Volume Effects on Human Thermoregulation in the Heat: Space Applications. Abstracts: Symposium on Space Operations, Applications and Research, 1993.

26. Young, A.J., M.N. Sawka, W.A. Latzka, R.R. Gonzalez and K.B. Pandolf. Effect of Aerobic Fitness on Thermoregulation. Medicine and Science in Sports and Exercise, 25:S62, 1993.

PRESENTATIONS:

27. Ljaamo, S.K. Cold Injury and Illnesses of the North. Current Topics in Environmental Medicine Course, Natick, MA, 4 May 1993.

28. Ljaamo, S.K. Clinical and Preventive Medicine Aspects of Cold Injury. Tri-Service Military Chapter, American College of Emergency Medicine meeting, San Antonio, TX, 12 May 1993.

29. Sawka, M.N. Temperature Regulation and Dehydration Effects During Exercise in the Heat. East Stroudsburg University, East Stroudsburg, PA, March 1993.

30. Sawka, M.N. Ergogenic Effects of Increased Red Blood Cell Volume. Meeting on Nonmaterial Individual Enhancement for Special Operation Force Operators, Natick, MA, April 1993.

31. Sawka, M.N. Performance Enhancements in Hot and Cold Environments. Current Concepts in Environmental Medicine Course, Natick, MA, May 1993.

32. Sawka, M.N. Hydration and Blood Volume Effects on Human Thermoregulation in the Heat: Space Applications. Space Operations, Applications and Research Symposium, Johnson Space Center, Houston, TX, August 1993.

33. Sawka, M.N. Thermoregulation, Circulation, Dehydration and Pathophysiology. Boston University, Boston, MA, September 1993.

34. Sawka, M.N. Effects of Blood Doping on Exercise Performance and Temperature Regulation Boston University, Boston, MA, October 1993.

35. Young, A.J. Metabolic Changes Induced by Heat, Cold and Altitude and the Role of Diet in Adaptation. Guest lecture to Advanced Exercise Physiology (HS731), Sargent College, Boston University, Boston, MA, February 1993.

36. Young, A.J. Responses to Endurance Training in Hot Versus Cold Water. Seminar for the Department of Physiology, School of Medicine, University of Occupational and Environmental Health, Kitakyushu, Japan, April 1993.

37. Young, A.J. Thermoregulatory Adaptations of Humans Repeatedly Exposed to Cold Air. Invited presentation in a symposium entitled, "Heat and Cold," held during the III World Congress of the International Society for Adaptive Medicine, Tokyo, Japan, April 1993.

38. Young, A.J. Effects of Cold and High Altitude on Physiological Responses to Exercise. Guest lecture to Advanced Exercise Physiology class (HS 731), Sargent College, Boston University, Boston, MA, November 1993.

KEY BRIEFINGS:

39. Sven K. Ljaamo, M.D., MAJ, MC. Prevention and Treatment of Injury and Illness in Cold Environments. U.S. Army Flight Surgeons Course, Ft Rucker, Alabama, 12 March 1993.

40. Sven K. Ljaamo, M.D., MAJ, MC. Classification, Presentation, Prevention and Review of Diseases of Significance in Somalia. U.S. Army 46th Combat Support Hospital, Ft. Devens, MA, 6 August 1993.

SIGNIFICANT TDY:

Bruce S. Cadarette. To collect data on thermoregulatory responses to specific tasks in the field while in MOPP 4, both with and without microclimate cooling; for P^2NBC^2 program, Aberdeen Proving Ground, MD, 18-30 July 1993.

Bruce S. Cadarette. To attend meeting of the Test Integration Working Group (TIWG) for Self-Contained Toxic Environment Protective Outfit (STEPO), representing USARIEM for the Heat Stress Testing planning, Gaithersburg, MD, 2-3 November 1993.

Leslie Levine. To attend meeting in support of Joint Service Lightweight Integrated Suit Technology (JSLIST) to discuss physiological testing for JSLIST garments, Quantico, VA, 8 April 1993.

Leslie Levine. To attend meeting in support of the development of a Health Hazard Assessment Desk Guide and to brief attendees on Heat Stress Testing section of Guidebook, Frederick, MD, 27-29 April 1993.

Leslie Levine. To attend Joint Service Lightweight Integrated Suit Technology (JSLIST) meeting, as member of

the Heat-Stress Subcommittee, to brief Project Managers on progress to date, Quantico, VA, 27-29 September 1993.

Leslie Levine. To attend Joint Service Lightweight Integrated Suit Technology (JSLIST) meeting to update Heat-Stress Subcommittee Project Managers on progress to date, San Antonio, TX, 1-3 November 1993.

Sven K. Ljaamo, M.D., MAJ, MC. To Pennington Biomedical Research Center, Louisiana State University, Baton Rouge, Louisiana, to serve as medical monitor/research medical officer in support of USARIEM Military Nutrition Division protocol, 13-27 June 1993 and 8-26 July 1993.

Michael N. Sawka, Ph.D. To perform field study "Effects of autologous erythrocyte infusion in sea level residents rapidly transported to high altitude", Colorado Springs, CO, July 1993.

Michael N. Sawka, Ph.D. To participate in "DOD/NASA Symposium on Space Operations and Applications Research", Johnson Space Center, TX, 2-5 August 1993.

Michael N. Sawka, Ph.D. To attend review of Navy's 6.1 Cold Research Program, Naval Medical research Institute, Bethesda, MD, 28-29 April 1993.

Michael N. Sawka, Ph.D. To attend planning meeting for JSLIST Program, Quantico, VA, 7 April 1993.

Michael N. Sawka, Ph.D. To attend P^2NBC^2 TSAG and JWIG meetings, 20-21 January 1993.

C. Bruce Wenger, M.D., Ph.D. To discuss data analysis for the study, "Heat Injury Among Marine Recruits", Washington, DC and Bethesda, MD, 20-21 January 1993.

C. Bruce Wenger, M.D., Ph.D. To discuss data analysis and retrieve frozen plasma samples for the study, "Heat Injury Among Marine Recruits", 28-29 November 1993.

Andrew J. Young, Ph.D. To participate in the 33rd meeting of Working Party 61, Aerospace Medicine and Life Support

Systems, of the Air Standardization Coordinating Committee, as US Army Project Officer for Project Group 114, "Aeromedical Considerations of Thermal Stress and Survival", November 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Michael N. Sawka, Ph.D., Division Chief. Editorial Board, Journal of Applied Physiology; Editorial Board, Aviation, Space and Environmental Medicine; Editorial Board, International Journal of Sports Medicine; Associate Professor, Institute of Health Professions, Massachusetts General Hospital, Boston, MA; Associate Professor, Department of Health Sciences, Boston University, Boston, MA; Chair, Project Review Committee, American College of Sports Medicine; Member, Position Statement Ad-Hoc Committee on Fluid Replacement during Exercise, American College of Sports Medicine; Member, Visiting Scientists for Minority Institutions Programs, American Physiological Society; Member, Nuclear/Biological Chemical Protective Equipment Subgroup, Chemical Defense Technical Cooperation Program; Member, Physiological and Psychological Effects of Nuclear, Biological and Chemical and Sustained Operations on Systems in Combat Program (P^2NBC^2); Reviewer, Acta Physiologica Scandinavica; American Journal of Physiology; Aviation, Space and Environmental Medicine, Chest; European Journal of Applied Physiology, International Journal of Sports Nutrition; International Journal of Sports Medicine; Journal of Applied Physiology; Life Sciences; Medicine and Science in Sports and Exercise; Undersea Biomedical Research; The Journal of the American Medical Association.

Beau J. Freund, Ph.D., MAJ, MS. Fellow, American College of Sports Medicine; Chairman, Abstract Reviewer, for Fluid and Electrolytes Section, American College of Sports Medicine; Member, Project Review Committee, American College of Sports Medicine. Reviewer, Journal of Applied Physiology; American Journal of Physiology; Medicine and Science in Sports and Exercise.

Margaret A. Kolka, Ph.D. Member, USARIEM Scientific Review Committee. Reviewer, European Journal of Applied Physiology; Journal of Applied Physiology; American Journal

of Physiology (Reg. Int., Comp. Physiol.; American Journal of Physiology (Heart and Circulation);. Journal of Thermal Biology; Aviation, Space and Environmental Medicine.

Sven Knudsen Ljaamo, M.D., M.P.H., MAJ, MC. Staff Preventive, Occupational, General Medical Officer, U.S. Coast Guard Academy Dispensary, New London, CT. Licensure by State of Massachusetts Board of Medicine. Recognized and Board Acceptable by the American Board of Preventive Medicine. Provided special consultation to the White House Medical Office on prevention of injury and illness during travel within the Commonwealth of Independent States, for members of the Presidential and Vice Presidential official parties.

Lou A. Stephenson, Ph.D. Reviewer, Journal of Applied Physiology; Medicine and Science in Sports and Exercise.

C. Bruce Wenger, M.D., Ph.D. Member, Subcommittee (C95.1-IV Working Group 11 (Metabolism/Thermoregulation), American National Standards Institute, New York, NY; Reviewer, Journal of Applied Physiology, American Journal of Physiology, Medicine and Science in sports and Exercise, South African Journal of Science, IEEE Transactions on Biomedical Engineering, Pflugers Archiv/European Journal of Physiology, Canadian Journal of Physiology and Pharmacology, Chest, Physician and Sportsmedicine, Aviation, Space and Environmental Medicine.

Andrew J. Young, Ph.D. U.S. Army project Officer, Project Group 114, Aeromedical Considerations of Thermal Stress and Survival, Working Party 61, Air Standardization Coordination Committee. Editorial Board, Medicine and Science in Sports and Exercise; Member, Research Review Committee, American College of Sports Medicine. Reviewer, Medicine and Science in Sports and Exercise; Journal of Applied Physiology; Arctic; Aviation, Space and Environmental Medicine; American Journal of Physiology.

SIGNIFICANT VISITORS:

Professors Viktor Smirnovich Koscheyev, M.D., Ph.D. and Gloria Rakita Leon, Ph.D., University of Minnesota, Department of Psychology, for presentations on protective clothing ensemble research at Russia's "Special Center for Disaster Medicine - 'Protection'" (Moscow), and personality factors associated with success in women's antarctic crossing teams, 9-11 March 1993.

OCCUPATIONAL HEALTH AND PERFORMANCE DIRECTORATE

RESEARCH FINDINGS: EXECUTIVE SUMMARY

- Demonstrated that an increase in load during backpack load carriage caused greater forward trunk lean throughout the gait cycle thus decreasing the body's center of mass.

- Demonstrated that increasing walking speed during backpack load carriage is accompanied by equal percentage increases in stride frequency and stride length.

- Demonstrated that the increase in energy cost (13-18%) of physical exercise in MOPP IV is attributable to the weight and hobbling effect of the clothing and not to the mask.

- Determined that the energy cost of physical tasks requiring whole-body locomotion is significantly increased in MOPP IV and that this increase places greater physiological demand on women than men.

- Developed a new test to determine external force and power generated during maximal-speed elbow extension using video analysis of the horizontal ball throw.

- Demonstrated that an outside-the-boot ankle brace worn during parachuting is as effective in reducing ankle sprains in operational units as in the student populations previously studied.

- Demonstrated that certain military prototype pack designs such as the double-pack system may decrease physiological stresses and reduce blisters and some musculoskeletal complaints associated with strenuous road marching.

- Determined that frequent running is associated with more musculoskeletal injuries and reductions in the

amount of running may prevent injuries without adversely affecting physical fitness.

- Determined that age and arch height might be an important risk factor in screening male trainees and selecting them for specific tasks and missions.

- Determined that low levels of fitness may be the primary risk factor for injury rather than gender. Therefore, women and men of similar fitness levels can be expected to have the same risk for injury during military training.

- Determined that self reported alcohol consumption is a risk factor for musculoskeletal injury in female basic trainees.

- Determined that weak lower body and low back strength as well as low anaerobic power are risk factors for injury in female trainees.

- Determine that there were 1273 person days of limited duty in 110 injured trainees (averaging 11.6 limited duty days per person injured).

- Determined that injury incidence is lower in special forces soldiers when compared to the infantry but the injuries related to special forces training tend to be more severe in terms of lost duty time.

- Determined that injury incidence of combat engineers is slightly higher than infantry soldiers which may be attributed to their lower aerobic fitness levels when compared to infantry soldiers.

- Determined that using a self-rating questionnaire may be a practical and valid method of estimating level of fitness in epidemiologic studies.

- Determined norms for Army Physical Fitness Test results so that physical fitness levels of individual soldiers can be compared with those in other units and military populations in the United States.

- Demonstrated that the foot contact monitor may be a valid method of estimating the duration and intensity of exercise during field military operations.

- Demonstrated that the eccentric cycle exercise is a good model for studying muscle tissue damage and performance decrements and possibly may be applied to such strenuous military field activities as road marching.

- Determined that magnetic resonance imaging is a valid non-invasive method of studying the relationship between musculoskeletal structural changes, injuries and performance.

- Determined a method of studying changes in muscle carbohydrate stores with magnetic resonance spectroscopy and relating these changes to fatigue and possibly muscle injury during intense exercise.

- Demonstrated that tyrosine augmented the performance enhancing effects of sympathomimetic drugs during cold stress.

- Demonstrated that cold stress alters cholinergic function in the hippocampus and impairs memory.

- Assessed the neurochemical, anatomical and behavioral consequences of exposure to hypobaric hypoxia and tested a nutritional and pharmacologic intervention to prevent decrements in performance.

- Demonstrated that muscarinic type-2 (M2) antagonists increase hippocampal cholinergic neurotransmission.

- Evaluated the ability of melatonin to improve sleep and mental performance in Army Special Forces air crews.

- Determined that a prototype double pack did not significantly decrease ESQ symptomatology after a 20 km road march.

- Determined that the symptomatology and psychological moods of US Marine Corps volunteers were not significantly affected by administration of mefloquine.

- Demonstrated that wearing chemical protective clothing resulted in an early vigilance decrements and impaired marksmanship.

- Visual fields were significantly reduced during wear of the MOPP-IV ensemble due to the physical occlusion caused by the protective mask.

- Demonstrated that caffeine significantly increased the number of correct responses and decreased response times on a visual vigilance task, whereas diphenhydramine decreased the number of correct responses and increased response times.

- Coordinated with the Sustainability Directorate to update and upgrade the nutrient data base for military items.

- Demonstrated that a 15 percent increase in energy provision to Ranger students decreased weight loss and medical attrition and improved immune function.

- In collaboration with the Ranger Training Cadre at the mountain training site, developed a research paradigm to test performance enhancement ration components in a military relevant scenario.

- Utilized ILIR funds to build the foundation for a cell culture laboratory to support the immunological efforts of both Military Nutrition field studies and for collaboration with other USARIEM researchers working in other stress models.

- Identified iron, zinc, calcium, magnesium, vitamin B_6 and folate as potential problematic nutrients for female soldiers.

USARIEM
CY93

- Characterized nutritional stress during Special Forces Assessment Training; recommended glutamine supplementation to improve immune function.

- Established that individual metabolic variability of Special Forces soldiers is relatively small and a function of lean body mass at rest and a function of total body mass and exercise intensity during exercise.

- Demonstrated a 17 percent enhancement of running time endurance by timing of carbohydrate supplements for Special Operation Forces soldiers.

- Assisted in the fielding of the first improvement of the survival ration since 1960.

- Developed a series of nutrition education materials to support Army Nutrition Initiative and Health People 2000 goals.

- Conducted Committee on Military Nutrition Research workshop that helped define research approach for ARMY STO on Nutritional Strategies.

- Installed first Local Area Network in the Institute to link investigators and improve data management, transfer, and analysis.

- Participated in the Women's Research Issues Workshop at Fitzsimons Army Medical Center.

- Provided research results that led to the revision of Surgeon General nutrition policy extending MRE feeding guidance from 10 days to 21 days (as the sole source of food).

- Published soldier and small unit leader guide/technical note "Nutrition for Health and Performance: Nutritional Guidance for Military Operations in Temperate and Extreme Environments".

- Provided evaluation of the evening meal optional policy to the U.S. Military Academy, West Point.

- Established that the nutritional merit of food intakes of West Point cadets was positively related to the number of meals cadets consumed in the Cadet Mess.

PUBLICATIONS:

1. Vogel, J.A., B.H. Jones, P.B. Rock and G. Havenith. Environmental considerations in exercise testing and training. In: ACSM Resource Manual Guidelines for Exercise Testing and Training, 2d edition, Philadelphia: Lea and Febringer, pp. 129-147, 1993.

2. Vogel, J.A. Obesity and its relation to physical fitness. In: Challenges in Military Health Care - Perspectives on Health Status and Provision of Care, J. Stanley and J.D. Blair (eds.), New Brunswick, NJ: Transactions Publishers, pp. 55-71, 1993.

3. Vogel, J.A. and A.K. Gauger. An annotated bibliography of research involving women, conducted at the US Army Research Institute of Environmental Medicine. USARIEM Technical Note TN 93-5, May 1993.

PRESENTATIONS:

4. Vogel, J.A. US Army physical fitness and performance research subthrust. ASBREM JTCG-5 Thrust Area Program Review, San Diego, CA, 23-25 February 1993.

5. Vogel, J.A. Preliminary final report of NATO Research Study Group-17 (Biomedical Aspects of Military Training). NATO Defense Research Group Panel 8 (Defense Applications of Human and Bio-medical Sciences, NATO HQ, Brussels, Belgium, 21-22 April 1993.

6. Vogel, J.A. FY 93 Science & Technology Review of ASBREM JTCG-5 Operational Medicine & Performance Research Program. Fort Detrick, MD, 25-26 August 1993.

USARIEM
CY93

KEY BRIEFINGS:

7. James A. Vogel, Ph.D. Muscle strength evaluation and physical task performance of female Army accessions. Briefing presented to LTG Carney, Army Deputy Chief of Staff for Personnel. Pentagon, 31 March 1993.

SIGNIFICANT TDY:

James A. Vogel, Ph.D. Represent Research Study Group-17 to Panel 8 Meeting of NATO Defense Research Group, NATO Headquarters, Brussels, Belgium, 19-23 April 1993.

James A. Vogel, Ph.D. Chair seventh meeting of NATO Research Study Group-17 (Biomedical Aspects of Military Training), Portuguese Military Academy, Lisbon, Portugal, 20-24 September 1993

James A. Vogel, Ph.D. Represent US Army to The Technical Cooperative Program Subgroup U Action Group-12 (Physical Performance Enhancement of Elite Combat Units) second meeting, San Diego, CA, 2-4 November 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

James A. Vogel, Ph.D., Research Director. Adjunct Professor, Department of Health Sciences, Boston University. Chairman, NATO Research Study Group-17, "Biomedical Aspects of Military Training". US Army representative to The Technical Cooperative Program UAG-12, "Performance Enhancement of Elite Military Units." Trustee, New England Chapter, American College of Sports Medicine. Associate Editor, Journal of Strength and Conditioning Research. Abstract Review Leader, American College of Sports Medicine.

MILITARY NUTRITION DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Assessment of the Adequacy of Nutritional Intakes of Female Soldiers During U.S. Army Basic Training. A study was conducted to determine how well military feeding addresses the nutritional requirements of female soldiers. The dietary intake of 49 female soldiers participating in a basic training cycle was recorded for 7 consecutive days using a visual estimation technique. The soldiers received 3 meals/d served cafeteria-style at a dining facility or a field site. Mean energy intake was 2592 kcal/d (12.6% protein, 56.3% carbohydrate, 32.5% fat), meeting 108% of the Military Recommended Dietary Allowances (MRDA) for energy. Body weight before and after the 8-week training was similar ([Mean±SD] 63.4±9.2 kg vs. 64.1±8.0 kg, respectively); however, body fat decreased (31.9±5.9% vs. 29.5±5.5%, $p<0.01$) and fat free mass increased (42.9±4.8 kg vs. 45.1±4.9 kg, $p<0.01$). Changes in body fat did not correlate with energy intakes ($r=-0.22$) suggesting that the changes in body composition were primarily the result of the physical training. Mean intakes of vitamin B_6, folate, Ca, Mg, Fe, and Zn were suboptimal (76%, 65%, 91%, 89%, 90%, and 75% of MRDA, respectively), which reflected the inadequate nutrient density of the menu provided. Even though study mean nutrient intakes were marginal at worst, some individuals had deficient mean intakes, i.e., less than 60% MRDA for vitamin A (3 soldiers), vitamin C (4), vitamin B_{12} (3), vitamin B_6 (9), folate (20), Ca (9), Mg (4), and/or Zn (9).

2. Nutrition Knowledge and Beliefs of Female Soldiers. Nutrition knowledge (factual understanding of nutrition) and beliefs (personal assumption about nutrition topics) may influence food selection which, in turn, establishes nutritional intakes and ultimately health. A study was conducted to assess the nutrition knowledge and beliefs of young women attending U.S. Army Basic Training. The results of this study indicate that nutrition knowledge is not always correlated with nutrition practices. Female

soldiers (n=157) were asked to select from a list of paired foods "the food choice that would help them practice better nutrition," e.g., select between whole milk versus low-fat milk, baked versus fried foods, fresh fruit versus pastries, etc. Mean correct response was 6.5 out of 7 (SD ±1.1; 92.9%), indicating good knowledge of nutrition. However, when hypothetically asked to choose from a similar list of foods which foods they would actually select if given the choices, the soldiers made the nutritious choice only 3.6 out of 6 instances (±1.8; 60%). The difference between nutrition knowledge and presumed dietary behavior was statistically significant ($p<0.01$). Thus, dietary behaviors do not seem to reflect the apparently adequate nutrition knowledge. Nutrition knowledge (n =157) scores significantly ($p\leq0.05$) increased from the pre- to the post-Basic Training administration (mean±SD: 63.60±12.93% and 68.55±12.14%, respectively). However, the percent of soldiers making the correct choice on the nutrition belief questions was similar between the pre- and the post-administration of the questionnaire. The nutrition knowledge of female soldiers entering the U.S. Army Basic Training in 1993 (n=157) was compared with the nutrition knowledge of those who entered training in 1988 (n=37). Their nutrition knowledge was not significantly different (mean percent correct response was 63.60±12.93% and 66.02±11.99% [mean ± SD], respectively). Likewise, the percent of soldiers making the correct choice on the nutrition belief questions was similar between the 1993 and the 1988 soldiers, when deciding which foods to choose to help them practice good nutrition or to lose weight.

3. Ethnic/Minority Nutrition. In a retrospective study conducted in FY92 to determine differences in nutritional intake of soldiers due to ethnicity, it was concluded that the available nutritional database of minority groups is small and fragmentary and that a larger database is needed. A survey instrument was designed to assess acculturation level and the prevalence of food intake problems encountered by minority groups in the U.S. Army to determine the need for educational programs and the addition of more ethnic foods to military menus. This

survey instrument will become a standard assessment tool in all of our nutrition assessment studies.

4. Special Operations Forces (SOF) Individual Operational Ration. This study evaluated both intra- and inter-individual variation in substrate utilization during repeated bouts of prolonged, treadmill exercise and recovery. Additionally, this study examined the effects of carbohydrate supplementation and the timing of the carbohydrate supplement administration on the metabolic response to exercise. Eighteen SOF soldiers resided in a metabolic ward for the 11-day research period. Diet, hydration status, energy expenditure, and ambient conditions were controlled. Dietary intake of carbohydrate (CHO) and protein (PRO) was controlled to simulate the average daily intake in a field setting (4 g CHO/kg body weight (BW) and 1.5 g PRO/kg BW; fat intake was set at a level to maintain BW). A placebo (CHO_0) and two CHO treatments were provided to each subject: 2.2 g CHO/kg BW immediately after the morning exercise (CHO_1) and 1.0 g CHO/kg BW immediately after the morning exercise and 0.4 g CHO/kg BW X 3 at 20-minute intervals during the afternoon exercise (CHO_2). On days 4, 7, and 10, soldiers performed a high-intensity two-hour treadmill run in the morning. After a seven-hour rest, the volunteers then performed a treadmill run-to-exhaustion. Respiratory gases were sampled every 20 minutes during exercise and recovery. Results indicate that variation in substrate utilization within and between individuals during both the morning and afternoon exercise trials was small (coefficient of variation in respiratory quotient (RQ) = 1-5%). Further, RQ was significantly higher in the CHO_1 and CHO_2 trials ($P>0.05$) indicating that the CHO that was ingested during exercise was quickly utilized. In conclusion, substrate utilization during exercise was determined by substrate availability and exercise intensity. Therefore, recommendations for optimal nutritional support during mission deployment may be made on the basis of body weight, predicted energy expenditure, and exercise intensity.

5. Performance Enhancing Ration Components (PERC) Project. Two studies of potential PERC items were conducted. In the initial PERC endeavor, a study was

conducted to examine the effects of a liquid carbohydrate supplement on work performance of Special Operations Forces soldiers during an operationally modeled laboratory endurance test. Subjects completed a 2-hour treadmill run in the morning; following a 7-hour rest, subjects performed a treadmill run to exhaustion. Consumption of supplemental carbohydrate following the morning run resulted in a 6% increase in run-to-exhaustion time. Ingestion of carbohydrate after the morning run and during the afternoon run (total amount of supplemental carbohydrate provided was equal in both situations) effected a remarkable 17% increase in run-to-exhaustion time. The results of this study clearly demonstrate that supplemental carbohydrate enhances physical performance in the military setting. These data also suggest that the timing of supplementation has important ramifications. Data from this project will be presented at the Army Science Conference, June 1994. The second PERC study was conducted to determine whether drinking a carbohydrate-electrolyte beverage (CEB) rather than water during field training would improve physical performance of soldiers. In this study, Army Rangers performed three days of typical field activities (i.e., rucksack marching, mountain climbing, etc.) while consuming one of three beverages: CEB, flavored placebo, or water. Physical performance measurements included a timed mountain-climbing performance, a timed foot race, and marksmanship. Numerous physiological and immunological parameters were also measured. Data analysis is in progress. Additionally, a protocol to examine the effects of caffeine on physical performance and mood state has been submitted to the USARIEM Scientific Review Committee and is currently under review. Physical performance measurements to be performed include pushups, situps, and 2-mile run; perceived exertion will be assessed, as well. The study will also test the hypothesis that a high dose of caffeine will adversely affect mood state, as has been shown in some previous studies. Glutamine has been incorporated into the PERC program for evaluation of its potential to decrease the rate of attrition due to infection of soldiers involved in highly strenuous training (i.e., Ranger training). Previous studies with Ranger and SOF soldiers revealed a suppression of immune function in subjects undergoing training that involved intense stress and underfeeding.

Clinical nutrition studies of hospitalized patients have shown that supplemental glutamine may decrease the incidence of infection. A protocol to test this hypothesis is under development.

6. Performance Nutrition. The Performance Nutrition Intervention Project is a pilot program to evaluate the impact of sports nutrition education and menu modification on nutrition knowledge, attitudes, and behaviors of service members in a variety of physically demanding training situations. This project supports a FY92 DOD Food & Nutrition RDTE&E requirement to develop a nutrition education package for the soldier on sports nutrition and has been partly funded by congressional health promotion money and Marine Corps funds. In support of the education component of the program, a variety of militarily relevant sports nutrition materials are being developed and produced in conjunction with a civilian contractor. The materials consist of six videotape presentations, four 30- to 60-second "commercials," scripted 35-mm slide shows, companion manuals/workbooks for participants, instructor resource manual, ten table tents, and four brochures. Focus group interviews were conducted with Army and Marine Corps personnel in order to obtain the needs, perceptions, and interests of the potential program audience as well as the program presenters. The information obtained through these focus groups was used in planning the intervention program. Planning and analysis of a 30-day training table menu is in progress.

7. Multistressor Evaluation of Ranger Training. The Ranger Training Brigade requested that USARIEM conduct a medical evaluation of the stress of Ranger training. Baseline data collected during 1991 identified excessive weight loss as a problem contributing to medical attrition, impaired immune response and loss of lean body mass and muscle strength (USARIEM Technical Report T13-92). USARIEM reviewed the results of this assessment with the Committee on Military Nutrition and suggested that the caloric content of the Ranger trainee ration be increased 15 percent through nutritional supplements to lessen the severity of the caloric restriction that accompanies Ranger training. The influence of a 15 percent increase in energy

provision was studied employing nutritional, immunological, physiological, and psychological assessment techniques. Changes in body composition and energy expenditure were also measured. Total body weight loss was reduced by 2.1 kg compared to the 1991 study. The loss of lean body mass was reduced 11 percent compared to the previous study. The results of this study demonstrated that a 15 percent increase in energy intake provided to Ranger trainees significantly reduced total weight loss during the 8-1/2 week training course. As a result, lean body mass loss was reduced, greater upper body strength was retained, immune function was improved, and the magnitude of medical attrition was reduced. Immune function parameters were improved. Medical attrition was decreased although it is unclear if that was a direct result of the increase in energy provision. Significant declines in psychomotor function and cognitive ability (up to 33%) were also noted during Ranger training. It remains to be established if these declines are the result of energy deficit, sleep restriction, other stress, or a combination of all of these stressors. Based upon the results of these studies, the Ranger cadre have reduced the food deprivation from only one MRE/day (1300 kcal) to three MRE/2 days (1950 kcal/day) during the field training exercise portions of the school. Additionally, the documentation of medical problems encountered during Ranger training has permitted the school to add additional medical staff at each of the four training sites. Although the increase in calories had beneficial effects, there was still evidence of some impairment of immune response. A nutritional supplement, glutamine, has been proposed to strengthen the reduced immune response observed during Ranger training. Glutamine will be tested with the SOF prior to testing with Rangers. Pending the outcome of the SOF pilot study, glutamine supplementation with Ranger students could begin in the 4th quarter FY 94 or 1st Quarter FY 95.

8. Military Nutrition Division LAN. The Banyan VINES network, compatible with the backbone installed at US Army Natick Research Development and Engineering Center, was installed for the Military Nutrition Division. This was accomplished after a thorough front-end analysis and a comparison of three possible network operating systems.

The network will be used to connect personnel in various locations and provide a link for data transfer during our field studies. The network will give all members of the Division a means of using electronic mail and a connection to the VAX 6510.

9. Nutrient Database for Military Rations. The Military Nutrition Division, USARIEM, has been working with the Sustainability Directorate, NRD&EC, to upgrade the nutrient data base for military rations. This information will be used for the USARIEM intake studies and by the Sustainability Directorate for nutrition labeling. More accurate information will be collected in the future in a manner which reflects the way the foods are eaten during intake studies. In addition, the nutrient data base will contain information on dietary fiber, copper, and the saturated and unsaturated fatty acids in the military food components. The final product of the effort will be a complete 30-nutrient profile for the military foods that corresponds to the format of the USDA Survey data base.

PUBLICATIONS:

1. Askew, E.W. Hydration for top physical performance. Olympic Coach, Vol. 3, No. 3:12-13, 1993.

2. Askew, E.W. Nutrition and performance at environmental extremes. In: Nutrition in Exercise and Sport. Second Edition. I. Wolinsky and J.F. Hickson, Jr.(Eds.), CRC Press, Boca Raton, FL, Chap. 19, pp. 455-474, 1993.

3. Baker-Fulco, C.J. and S.A. Torri. Sports nutrition in the military. Scan's Pulse, 11:16-17, 1993.

4. Jones, T.E., S.H. Mutter, J.M. Aylward and E.W. Askew. Nutrition and hydration status of aircrew members consuming an improved survival ration during a simulated survival scenario. In: The Support of Air Operations Under Extreme Hot and Cold Weather Conditions. AGARD Conference Proceedings No. 540, paper 10. NATO Advisory Group for Aerospace Research and Development, 1993.

5. King, N., C.S. Fulco, C.J. Baker-Fulco, S. Muza, T. Lyons and A. Cymerman. Field trial of caffeine on physical performance at altitude: An attempt to overcome the challenge. USARIEM Technical Report No. T8-93, June 1993.

6. King, N., T.W. Odom, H.W. Sampson and S.L. Pardue. In ovo administration of boron or sodium aluminosilicate alters mineralization in the turkey. Nutr. Res. 13:77-85, 1993.

7. King, N., S.H. Mutter, D.E. Roberts, M.R. Sutherland and E.W. Askew. Cold weather field evaluation of the 18-Man Arctic tray pack module, the Meal, Ready-to-Eat, and the Long Life Ration Packet. Milit. Med. 158, 7:458, 1993.

8. King, N, K.E. Fridlund, and E.W. Askew. Nutrition issues of military women. J. Am. Col. Nutr. Women's Health and Nutrition Issues, 12:344-348, August 1993.

9. Klicka, M.V., D.E. Sherman, N. King, K.E. Friedl and E.W. Askew. Nutritional assessment of cadets at the U.S. Military Academy: Part 2. Assessment of Nutritional intake. USARIEM Technical Report No. T94-1, 1993.

10. Kramer, F.M., K.L. Rock, M. Salomon, L.L. Lesher, D.B. Engell, Thomas C. and S.D. Gagne. The relative acceptability and consumption of the current T ration with and without new breakfast and dinner menus. Technical Report Natick/TR-93/031, 1993.

11. Lester, L.S., L.L. Lesher, M. Salomon, D.B. Engell, S.L. Dewey, J.L. Ward II, C. Thomas and J. Kalick. Nutritional and hedonic consequences of consuming the Meal, Ready-to-Eat (MRE) VIII or the Soldier Enhancement Program (SEP) MRE. Technical Report Natick/TR-93/015, 1993.

12. Martinez-Lopez, L.E., K.E. Friedl, R.J. Moore and T.R. Kramer. A longitudinal study of infections and injuries of Ranger students. Milit. Med. 158, 7:433, 1993

13. Moore, R.J., K.E. Friedl, R.T. Tulley and E.W. Askew. Maintenance of iron status in healthy men during an

extended period of stress and physical activity. Am. J. Clin. Nutr. 58:923-7 1993.

14. Rose, M.S., R. Moore, R. Mahnke, E. Christensen and E.W. Askew. Weight reduction techniques adopted when weight standards are enforced. USARIEM Technical Report No. T4-93, 1993.

15. Thomas, C.D., E.W. Askew, C.J. Baker-Fulco, T.E. Jones, N. King, D.A. Jezior and B.N. Fairbrother. Nutrition for health and performance/Nutritional guidance for operations in temperate and extreme environments. USARIEM Technical Note No. 93-3, 1993.

16. Thomas, C.D., C.J. Baker-Fulco, T.E. Jones, N. King, D.A. Jezior, B.N. Fairbrother, K.L. Speckman and E.W. Askew. Nutritional guidance for military field operations in temperate and extreme environments. USARIEM Technical Note No. 93-8, 1993.

ABSTRACTS:

17. Askew, E.W., J.A. Edwards, R.W. Hoyt, N. King, C.S. Fulco, E.J. Iwanyk and A. Cymerman. Work at moderate altitude: how severe is the metabolic stress? J. Wilderness Med. 4:77, 1993.

18. Askew, E.W., R.J. Moore and K.E. Friedl. Nutritional status and body composition changes during sustained physical work and calorie deprivation. FASEB J. 7:A613, 1993.

19. Baker-Fulco, C.J. and E.W. Askew. Dietary assessments of military populations. FASEB J. 7:A411, 1993.

20. Burstein, R., Y. Epstein, W.A. Coward, M.B. Sawyer, D. Moran, C.F. Irving, O. Shpilberg, E.W. Askew, B. Lev and M. Wiener. Energy balance in subjects performing physical efforts in cold climate. Med. Sci. Sports Exerc. Supplement 25:231, 1993.

21. Jones, T.E., R.W. Hoyt, J.P. DeLany, R.L. Hesslink and E.W. Askew. A comparison of two methods of measuring water intake of soldiers in the field. FASEB J. 7:A610, 1993.

22. King, N., E.W. Askew, J.P. DeLany, A.J. Young and D.E. Roberts. The effect of cold environment on energy expenditure and nitrogen balance. J. Wilderness Med. 4:75, 1993.

23. King, N., K.E. Fridlund, B.S. Beam, E.W. Askew, E.G. Szeto, R.W. Rose and D.E. Carlson. Nutritional intakes of minority groups in the U.S. Army. FASEB J. 7:A292, 1993.

24. Moore, R.J., K.E. Friedl, R.T. Tulley and E.W. Askew. Normal iron (Fe) status during physical training with low Fe intake and rapid weight loss. FASEB J. Vol. 7, No. 3, 3000, p. A517, 1993.

25. Murphy, C., D. Otto, C. Long, D. Heimburger and J. Geiger. Effects of intradialytic parenteral nutrition (IDPN) on oral intake and whole body protein turnover (WBPT) in underweight hemodialysis (HD) patients. FASEB J 7:A377, 1993.

26. Shippee, R.L., K. Friedl, R. Tulley, E. Christensen and J. Arsenault. Changes in plasma copper, zinc, and iron concentrations of young males during 8 weeks of extreme physiological and psychological stress. In: Proceedings of the 34th Annual Meeting of the American College of Nutrition, p. 614, 1993.

27. Thomas, C., K. Friedl, M. Mays and E.W. Askew. Effect of extended consumption of Meal, Ready-to-Eat on nutritional status and performance of soldiers. FASEB J. 7:1707, 1993.

PRESENTATIONS:

28. Askew, E.W. Background on and procedures of the National Academy of Sciences Committee on Military Nutrition Research at a Committee meeting "Review of the results of nutritional intervention, Ranger Training Class 11-92 (Ranger II)." Washington, DC, March 1993.

29. Askew, E.W. "From Desert Storm to Operation Restore Hope: How the U.S. Army ensures soldier nutrient requirements are met," American Society of Clinical Nutrition Public Information Symposium, Federation of Experimental Biology Meetings, New Orleans, LA, March 1993.

30. Askew, E.W. Lectured on "Nutrition for extreme environments," AMSC Postgraduate Nutrition Course. Walter Reed Army Medical Center, Washington, DC, April 1993.

31. Askew, E.W. "Nutrition and hydration in the field" as part of the Moderation of Performance Degradation: Advice and Solutions to Provide Your Commander section of the Current Concepts in Environmental and Operational Medicine Course. Natick, MA, April 1993.

32. Askew, E.W. Guest panelist, Nutrition in Military Medicine section of the course, Malnutrition in the Hospitalized Patient: Optimal Therapeutic Intervention, presented by the Department of Continuing Medical Education, Harvard Medical School, and the Nutrition Support Service, New England Deaconess Hospital, Boston, MA, May 1993.

33. Askew, E.W. Workshop and public hearing on the topic, "Should the Recommended Dietary Allowances be Revised?" Invited panel participant and spoke on "Military recommended dietary allowances: How the Armed Services use the RDA's." Washington, DC, June 1993.

34. Askew, E.W. Invited participant in the National Academy of Sciences review on "The Effects of Diet on Performance: An Initial Review. Washington, DC, October 1993.

35. Askew, E.W. "Nutritional enhancement of soldier performance at the U.S. Army Research Institute of Environmental Medicine, 1985-1992." Presented at Committee on Military Nutrition workshop: Food Components to Enhance Performance, Natick, MA, November 1993.

36. Baker-Fulco, C.J. "Dietary intakes during military exercises." Workshop on Strategies to Overcome

Underconsumption of Field Rations sponsored by the National Academy of Sciences Committee on Military Nutrition Research, Natick, MA, November 1993.

37. Jones, T.E. "Nutrition and hydration status of aircrew members consuming an improved survival ration during a simulated survival scenario" at Advisory Group for Aerospace Research and Development's Aerospace Medical Panel symposium on: The Support of Air Operations under Extreme Hot and Cold Weather Conditions. Victoria, British Columbia, Canada, May 1993.

38. King, N. Invited participant to workshop with Congressional interest on women's research issues. Fitzsimons Army Medical Center, CO, April 1993.

39. King, N. "Nutritional intakes of ethnic groups and women in the U.S. Army," Postgraduate Nutrition Short Course, Walter Reed Army Institute of Research, Washington, DC, April 1993.

40. King, N. and R.L. Shippee. Designed and set up exhibit outlining USARIEM mission at the Research and Development Associates Fall '93 meeting, Boston, MA, October 1993.

41. King, N. "Nutritional issues unique to military women." Race and Ethnic Studies Institute Brown Bag Seminar, Texas A&M University, College Station, TX, October 1993.

42. King, N. Military Nutrition Division research program. Annual meeting of the MRDC Fellows, Natick, MA, December 1993.

43. Shippee, R.L. Ranger II data discussion and coordination with WRAIR and USDA representatives, Washington, DC, March 1993.

44. Shippee, R.L. Introduction, objective, experimental design and constraints, food/nutrient consumption, energy expenditure, and vitamin and mineral status at a "Review of the Results of Nutritional Intervention, Ranger Training

Class 11-92 (Ranger II)" sponsored by the Committee on Military Nutrition Research, Washington, DC, March 1993.

45. Shippee, R.L. Guest speaker at the Mary Lipscomb Hamrick AMSC Research course, Silver Spring, MD, August 1993.

46. Shippee, R.L. "Changes in plasma iron, copper, and zinc concentrations of young males during 8 weeks of extreme physiological and psychological stress" at the 34th annual meeting of the American College of Nutrition, October 1993.

KEY BRIEFINGS:

47. Eldon W. Askew, Ph.D., COL, MS. Briefed on the sub-thrust nutritional strategies for the U.S. Army at the Armed Services Biomedical Evaluation and Management (ASBREM) Thrust review of occupational medicine and performance. Appointed coordinator for the sub-thrust on nutritional strategies. Naval Health Research Center, San Diego, CA, February 1993.

48. Eldon W. Askew, Ph.D, COL, MS. Briefed USARIEM nutrition program overview: Performance Enhancing Ration Components, SOF individual operation ration, SOF assessment course multi-stressor study at the Nonmateriel Individual Enhancement for SOF Operators (NIESO)/Focus on "Skin-In." Natick, MA, April 1993.

49. Eldon W. Askew, Ph.D., COL, MS. Military Nutrition Division mission and key activities briefed to Colonel Lee and Major Wong, Senior Medical Officers, Republic of Singapore, Natick, MA, August 1993.

50. Eldon W. Askew, Ph.D., COL, MS. Military Nutrition Division mission and activities briefed to LTC Yoram Epstein, Israel Defence Forces Medical Corps, Natick, MA, August 1993.

51. Eldon W. Askew, Ph.D., COL, MS. USARIEM interface with the Special Forces briefed to Colonel J.D. Sankey,

Deputy Commander, British Army Staff, Natick, MA, September 1993.

52. Eldon W. Askew, Ph.D., COL, MS. Military nutrition research program to Dr. W. Selvamurthy, Government of India, Ministry of Defence, Natick, MA, September 1993.

53. Carol J. Baker-Fulco. Overview of Military Nutrition Division data submission to the Third Scientific Report of the National Nutrition Monitoring and Related Research program. Life Science Research Office, Federation of American Societies for Experimental Biology, Bethesda, MD, November 1993.

54. Carol J. Baker-Fulco. Update on Military Nutrition Division Research and Performance Nutrition Intervention Project. Army Nutrition Planning Committee, Washington, DC, December 1993.

55. Nancy King, Ph.D., LTC, SP. Military Nutrition Division mission and key activities briefed to Thomas Drummond and Georges Trottier (scientific and technical liaison between the six Canadian defence research establishments and all U.S. DOD research facilities), Natick, MA, June 1993.

56. Ronald L. Shippee, Ph.D., MAJ, MS. Briefed "A Practical Example: Ranger School 1991/1992" as part of the Moderation of Performance Degradation: Advice and Solutions to Provide Your Commander section of the Current Concepts in Environmental and Operational Medicine Course, Natick, MA, April 1993.

57. Ronald L. Shippee, Ph.D., MAJ, MS. Military Nutrition field activities with the Special Forces briefed to Colonel Lee and Major Wong, Senior Medical Officers, Republic of Singapore, Natick, MA, August 1993.

SIGNIFICANT TDY:

Eldon W. Askew, Ph.D., COL, MS and Tanya Jones. Site visit to coordinate cooperative agreement with LSU and to

coordinate metabolic ward study, Pennington Biomedical Research Center, Baton Rouge, LA, April 1993.

Eldon W. Askew, Ph.D., COL, MS. The 40th annual meeting of the American College of Sports Medicine, Seattle, WA, June 1993.

Eldon W. Askew, Ph.D., COL, MS. Test, Schedule and Review coordination meeting on the Army Field Feeding System, Fort Detrick, Frederick, MD, June 1993.

Eldon W. Askew, Ph.D., COL, MS. To assist with mid-point data collection of Special Forces assessment class study, Fort Bragg (Camp MacKall), NC, June 1993.

Eldon W. Askew, Ph.D., COL, MS. To assist with start of metabolic ward study and to review progress of grant tasks. Pennington Biomedical Research Center, Baton Rouge, LA, June 1993.

Eldon W. Askew, Ph.D., COL, MS. International Sport Nutrition Conference on ergogenic aids and performance, Colorado Springs, CO, September 1993.

Eldon W. Askew, Ph.D., COL, MS. DOD representative at Interagency Committee on Human Nutrition Research, Beltsville, MD, October 1993.

Carol J. Baker-Fulco. National Center for Health Statistics Consensus Workshop on Dietary Assessment, Richmond, VA, February 1993.

Carol J. Baker-Fulco. Interagency Board Meeting for Nutrition Monitoring, Washington, DC, September 1993.

Carol J. Baker-Fulco. Conducted focus groups for the Performance Nutrition Intervention video project, Camp Lejeune, NC, February 1993.

Barry Fairbrother, MAJ, British Special Projects Officer. Site visit to coordinate a study with a Special Forces Assessment and Selection Course, Fort Bragg, NC, February 1993.

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Barry Fairbrother, MAJ, British Special Projects Officer. Site visit and briefing for Special Operations Forces study, Fort Bragg, NC, April 1993.

Barry Fairbrother, MAJ, British Special Projects Officer, Ronald L. Shippee, Ph.D., MAJ, MS and study team. Special Forces 30-day study to assess the nutrition of soldiers during a Special Forces Assessment and Selection Course, Camp MacKall, Fort Bragg, NC, May/June 1993.

Tanya E. Jones. Conducted focus group sessions and met with command staff in support of the Special Operations Forces Individual Operational Ration project, Fort Bragg, NC, February 1993.

Tanya E. Jones and T. Clifton Murphy, LTC, SP. To recruit SOF soldier volunteers for the metabolic ward study, Fort Bragg, NC, May 1993.

Tanya E. Jones, Catherine L.V. Gabarée, T. Clifton Murphy, Ph.D., LTC, SP and study team members. Two-part Special Operations Forces (SOF) Individual Operational Ration metabolic ward study, Pennington Biomedical Research Center, Baton Rouge, LA, June/July 1993.

Nancy King, Ph.D., LTC, SP. Site visit and briefing to coordinate for study, Health, Performance, and Nutritional status of U.S. Army Women during Basic Training, Fort Jackson, SC, February 1993.

Nancy King, Ph.D., LTC, SP, T. Clifton Murphy, Ph.D., LTC, SP, Ronald L. Shippee, Ph.D., MAJ, MS and Doris Sherman. Members of study team analyzing the health, performance, and nutritional status of U.S. Army women during basic training, Fort Jackson, SC, May 1993.

T. Clifton Murphy, Ph.D., LTC, SP. Strategic Planning Conference for Health Promotion, Virginia Beach, VA, January 1993.

T. Clifton Murphy, Ph.D., LTC, SP and Nichol Hotson, MAJ, UK RLC. Site visit to brief brigade commander on Field

Feeding Hot Environment study for participation, Fort Bliss, TX, November 1993.

T. Clifton Murphy, Ph.D., LTC, SP. Conference "Making Fat Loss Work, Cooper Institute for Aerobics Research, Dallas, TX, September 1993.

Doris E. Sherman. Eighteenth National Nutrient Databank Conference, Baton Rouge, LA, May 1993.

Ronald L. Shippee, Ph.D., MAJ, MS. Site visits to plan and coordinate the Ranger performance enhancement (carbohydrate electrolyte solution) study. Fort Bragg, NC, Fort Lee VA, Fort Benning, GA, February 1993.

Ronald L. Shippee, Ph.D., MAJ, MS. Site visit to plan and coordinate the performance enhancement Ranger study, Dahlonega, GA, April 1993.

Ronald L. Shippee, Ph.D., MAJ, MS, Nicol Hotson, MAJ, UK RLC and study team. A performance enhancement (carbohydrate electrolyte solution) study with Ranger volunteers, Dahlonega, GA, August 1993.

Ronald L. Shippee, Ph.D., MAJ, MS. Consultation visit requested by Special Forces medical personnel on medical emergencies in a Special Forces assessment course, U.S. Army John F. Kennedy Special Warfare Training Center and School, Fort Bragg, NC, September 1993.

SIGNIFICANT VISITORS:

Ming Sun, Ph.D., a research assistant professor in the Department of Pediatrics of Vanderbilt University, Nashville, TN. He consulted on the installation of a respirometer and presented a seminar "Measurement of Human Energy Expenditure,"
January 1993.

Catherine Champagne, Ph.D., Alice Hunt, Ph.D., and Ray Allen, staff members of Pennington Biomedical Research, Baton Rouge, LA. They consulted on our joint Menu Modification project, February 1993.

Dr. Nesheim, Chairman, National Academy of Sciences Committee on Military Nutrition Research; Dr. Marriott, committee member; Dr. Yates, University of Southern Mississippi; Dr. Penlund, USDA, Fargo, North Dakota; Dr. Dwyer, Tufts University; and Dr. Horton, University of Vermont, were here to plan a future CMNR workshop on why soldiers do not consume adequate food during field exercises, April 1993.

Hal Goforth, Ph.D., Naval Health Research Center, San Diego, gave a seminar on "Longevity of Supercompensated Muscle Glycogen," May 1993.

Dr. Nesheim, Dr. Marriott, Dr. Horton, Dr. Dwyer, members of the Committee on Military Nutrition Research (CMNR) of the National Academy of Sciences, were here to conduct an initial planning meeting for a workshop that would cover Work in Cold and High Altitude Environments, August 1993.

Deirdre Douglass, Ph.D. and Susie McPherson, staff members of University of Texas at Houston coordinated on modifications to the university food intake analysis system, September 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Eldon W. Askew, Ph.D., COL, MS, Division Chief. U.S. representative to the Commonwealth Defence Science Research Organization, Food Science and Preventive Medicine Group. DOD representative to the U.S. Interagency Committee on Human Nutrition Research and the and the Interagency Board on Nutrition Monitoring and Related Research. Member, Nutrition Advisory Panel, U.S. Olympic Committee and invited contributor to the Olympic Coach journal. Invited journal reviewer International Journal of Sports Nutrition. American Institute of Nutrition/American Society for Clinical Nutrition Public Information Committee participant. National Academy of Sciences Institute of Medicine participant in workshop on Recommended Dietary Allowance revision.

Tanya E. Jones, M.S., R.D. Recipient of the prestigious Colonel Rohland A. Isker Award for the accelerated

development and fielding of the Food Packet Survival, General Purpose, Improved. Selected to receive the U.S. Army Natick Research, Development and Engineering Center Technical Director's Silver Award for Development.

Carol J. Baker-Fulco, M.S., R.D. Alternate DOD representative to the U.S. Interagency Committee on Nutrition Monitoring and Related Research.

MILITARY PERFORMANCE & NEUROSCIENCE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Demonstrated that administration of sympathomimetic drugs substantially increase the ability of tyrosine to protect against stress-induced behavioral decrements. Two sympathomimetic drugs, amphetamine and phenylpropanolamine effectively increased the beneficial effect of tyrosine on coping behavior during cold stress. Immediately following a 20 min long exposure to a cold water bath, which lowered core body temperature to 30° C, and behavioral stress (restraint), performance was assessed with the Porsolt swim test. This behavioral task assessed the ability of animals to respond appropriately to the environment. Animals pretreated with tyrosine in combination with either drug were less adversely affected by exposure to stress. The combination of tyrosine with either drug produced greater beneficial effects than the highest dose of tyrosine tested alone. These results demonstrate that a nutrient and over-the-counter drug combination may protect animals against the adverse effects of environmental and behavioral stress on ability to cope with the environment. In addition, the results of this study indicate the tyrosine's effects are attributable to increases in noradrenergic function.

2. Demonstrated that cold stress alters cholinergic function in the hippocampus and impairs memory. This project investigated the role of hippocampal cholinergic neurons in acute cold stress. Using in vivo microdialysis, changes in acetylcholine were monitored in cold stressed

animals and controls. Acetylcholine levels fell significantly during cold stress then sharply rebounded to above normal levels during recovery. Substantial decrements in learning and memory were present following cold stress. This information will be employed to design nutritional and/or pharmacologic strategies customized to alleviate the decrements in neurotransmission and behavior produced by specific environmental and other stressors.

3. Assessed the neurochemical, anatomical and behavioral consequences of exposure to hypobaric hypoxia and tested a nutritional and pharmacologic intervention to prevent decrements in performance. It was been found that significant cognitive deficits occur in rats exposed to altitudes of 19,500 ft or higher when learning and memory are assessed with the Morris water maze. Substantial reductions in the release of the neurotransmitter acetylcholine in the hippocampus were observed at 18,000 ft. There was evidence of morphological damage associated with exposure to a simulated altitude of 21,000 ft for four days. Restoration of acetylcholine levels to normal by either acute or chronic treatment with the drug nimodipine did not restore learning to normal. However, treatment with the nutrient tyrosine did significantly improve performance. Catecholaminergic neurotransmitter systems may therefore be responsible for the significant deficits in learning and memory seen in soldiers exposed to hypobaric hypoxia.

4. Demonstrated that muscarinic type-2 (M2) antagonists increase hippocampal cholinergic neurotransmission and determined the most potent candidate M2 for behavioral testing. Studies were conducted to examine the effects of a new class of drugs, muscarinic-type 2 (M2) antagonists, which may increase brain acetylcholine release. In previous studies we have demonstrated that cold exposure and hypobaric hypoxia decrease the release of acetylcholine in the hippocampus. Therefore, a compound that increases acetylcholine may prevent stress-induced decrements in learning and memory. M2 antagonists were directly administered to the hippocampus of rats via a microdialysis probe and the release of acetylcholine was measured using the same probe. Four different M2 antagonists were tested

at a range of doses. All significantly increased brain acetylcholine release. The most potent compound tested was AFDX-384. By enhancing the release of acetylcholine M2 antagonists may prevent decrements in learning and memory associated with exposure to environmental and behavioral stressors.

5. Evaluated the ability of melatonin to improve sleep and mental performance in Army Special Forces aircrews following rapid deployment across multiple time zones and exposure to multiple stressors. Melatonin, a naturally occurring substance released at night by the human pineal gland, was administered for several days prior to departure and after arrival in the new time zone melatonin. Cognitive performance was assessed daily using laptop computers and sleep time was measured with wrist worn activity monitors. Melatonin treatment prevented vigilance decrements that were observed in placebo-treated aircrew and ground crew members. Melatonin treated soldiers also were able to sleep for longer periods than placebo treated soldiers.

6. Demonstrated that moderate doses of caffeine improve visual vigilance. A specially designed test of visual vigilance intended to simulate sentry duty and other tasks requiring sustained visual vigilance was developed. The task, which is two hours in duration, was used to test the effects of 200 mg of caffeine on the performance of soldiers. Caffeine significantly increased the number of targets detected and decreased reaction time. Caffeine also had beneficial effects on the mood of soldiers; increasing vigor and decreasing fatigue and depression.

7. Designed and constructed a wrist-worn prototype vigilance monitor to be used in the field to continuously monitor and enhance vigilance, modify sleep/rest cycles and monitor environmental conditions. Information collected is recorded for later evaluation. The devices will continuously monitor a soldier's vigilance, sleepiness and sleep and when necessary, intervene to increase performance. Environmental parameters such as illumination, noise and ambient temperature are also monitored. Wrist worn prototype devices, controlled by

battery powered microcomputers with substantial on board memory have been fabricated and tested in the laboratory and field. A production design has been finalized and a number of devices are under construction. A detailed description of the device, including technical drawings, is nearing completion and will be used in filling patent applications.

8. Determined that a prototype double pack did not significantly decrease ESQ symptomatology after a 20 km road march. Soldiers often carry heavy loads (32-76 kg) when engaged in military operations. While a commander's goal is frequently to achieve rapid march times with minimal fatigue and discomfort, carrying heavy loads can lead to symptoms of body soreness, aches, pains, and tiredness. Loads which are evenly distributed about the center of mass of the body have a lower energy cost than loads carried entirely on the back and may alleviate symptomatology. Each of 21 male soldiers completed a 20 km road march as rapidly as possible while carrying either 34, 48, or 61 kg and while wearing either the standard US Army ALICE backpack or a prototype double-pack (intended to distribute the load equally between the front and back of the body). Symptomatology was assessed with the Environmental Symptoms Questionnaire (ESQ). Pre-march symptoms included feeling alert, good, and wide awake. Post-march symptoms included tiredness, muscle tightness, and soreness of the legs, feet, back and shoulders. Analyses of ESQ symptom factors showed (a) no significant effect of pack type; (b) significant effects of load indicating that as load increased, fatigue and muscle discomfort intensified and alertness and feelings of well-being diminished; and (c) significant pack x load interactions indicating that distress and heat illness indices were most intense at 61 kg with the double-pack. The double-pack did not alleviate symptoms as expected compared to the ALICE pack. Distress and heat illness indices were actually most intense with the 61 kg double-pack load. It is likely that the double-pack's front compartment reduced evaporation of sweat in the chest area, which may have impaired thermoregulation.

9. Through the administration of the USARIEM Environmental Symptoms Questionnaire (ESQ) and the Profile of Mood States (POMS), USARIEM personnel assessed the symptomatology and psychological moods of US Marine Corps research volunteers participating in a study of the tolerance of prophylactic mefloquine regimens. Marines (n=359) who volunteered for this 12-week study were randomly assigned to one of three drug conditions: weekly mefloquine (250 mg per week), loading dose mefloquine (750 mg mefloquine the first week followed by weekly doses of 250 mg), and chloroquine (300 mg per week). All Marines were administered the ESQ and the POMS prior to each drug administration. It was demonstrated that Marines using mefloquine were more likely to report symptoms of depression and sleep disturbance than those using chloroquine. Analysis of the POMS indicated that compared to other drug groups: (a) the mefloquine loading dose group reported more intense feelings of depression at the end of week 1, and (b) the weekly mefloquine group reported more intense feelings of depression at week 6. Although these differences were statistically significant, all means were within the normal range. Analysis of the ESQ indicated that there was a trend for proportionately more reports of unusual dream activity and sleep disturbance in the mefloquine groups. These data are important to assessing the efficacy and side effects of anti-malaria drugs in military personnel.

10. The feasibility of using off-the-shelf data visualization software to model the effects of environmental and operational stressors on rifle marksmanship performance was demonstrated. Data visualization software packages for MS/DOS-compatible, Windows-compatible, and Macintosh hardware were tested to determine the ease with which they could (a) fit curves to existing rifle marksmanship data and (b) provide mathematical algorithms describing the curve generation procedure. Although at least one package in each of the categories proved adequate to the task, a combination of MS/DOS and Windows-compatible software provided the greatest flexibility. Preliminary analysis of the best fitting curves suggests that rifle marksmanship performance is not a simple linear function of environmental/opera-

tional parameters. The models developed will assist in the prediction of the optimal length of assignments requiring sustained attention, target detection, and marksmanship skills, and thus, will assist the unit commander in scheduling assignments such as sentry duty.

11. A comparative analysis was conducted of the findings of laboratory studies on the effects of wearing chemical protective (CP) clothing on rifle marksmanship and on selected sensory and psychomotor tasks. Task performance in the Battle Dress Uniform (BDU) under thermoneutral conditions was used as a standard for comparison based on percent change, to evaluate the separate and combined effects of wearing CP clothing, exposure to ambient heat, and test duration. The findings indicated that wearing CP clothing resulted in an early overall impairment of task performance, but that the magnitudes of impairment did not increase progressively over time (up to six hours) beyond the initial impairment levels. Although wearing CP clothing under hot conditions led to the development of heat stress, and thus, limited test time to less than two hours, it did not degrade sensory or psychomotor performance beyond that observed under thermoneutral conditions for the same time period. Wearing CP clothing during heat exposure did, however, degrade rifle firing accuracy during the first two hours. Tasks involved in simulated sentry duty showed that wearing CP clothing intensified vigilance decrements and degraded rifle marksmanship.

12. Simultaneous psychological and ventilatory data were collected from exercising and sedentary soldiers with non-invasive procedures. Soldiers answered each problem on a cognitive performance task with a verbal response and a switch closure on one of two hand grips. The correlation of responses from different motor systems is being analyzed. We also developed an experimental procedure, a respiratory challenge, to identify soldiers who are vulnerable to the adverse effects of the chemical protective mask. A small port was added to the mask to allow breath-by-breath sampling of expiratory gases for analysis of ventilatory parameters. Simultaneous

psychological and ventilatory data were collected during each challenge.

13. During a P2NBC2 field study, factors predisposing soldiers to performance degradation and/ or noncompletion of a daily test session were identified. It was found that 31% and 57% of the soldiers requiring prescriptive inserts for the chemical protective masks did not have them issued for this or a prior field exercise. Such factors decrease military readiness or the effectiveness of military training. These data helped scientific personnel interpret the results of this field exercise, compare the exercise with other field studies, and identify predictors of soldier performance.

14. Under a Small Business Initiative Research (SBIR) contract, Technical Evaluation Research, Inc., (TERI) of Little Silver, NJ, evaluated the feasibility of an intelligent speech processor to reduce noise from speech (or other audio signals) based on the spectral characteristics of brief, successive samples of the signal. The processor "enhances" the signal before transferring it to other components for speech recognition processing. TERI demonstrated the feasibility of their prototype system for the Small Business Innovative Research Program (Phase I). In future efforts, their system will be miniaturized and configured on a PC plug-in card. TERI's signal-enhancing processor could enable automated collection of symptoms, moods, and performance data from soldiers in military training centers, the laboratory, or the field.

15. Long latency auditory evoked potentials (AEPs) were obtained from 18 male soldier volunteers (19-28 years) during concomitant performance of a visual vigilance task after administration of caffeine or diphenhydramine. The records were examined for changes in response to administration of caffeine (200 mg) and diphenhydramine (50 mg). The AEPs were also analyzed for time effect changes for up to two hours post drug administration. Significant increases in N1 and P2 latencies and decreases in amplitude voltage were exhibited over time. The P2-N2 amplitude showed a significant increase for the diphenhydramine condition 40 mins post drug ingestion. This increase is

attributed to the auditory stimulus acting as a diversion to keep participants awake while performing the visual vigilance task under the sedative effects of diphenhydramine. The observed evoked potential changes indicate that diphenhydramine had a direct effect on the histaminergic system during performance of a vigilance task.

16. The size and extent of visual fields were studied with 16 female soldiers exposed to temperate (70°F/35%RH) and hot (91°F/61%RH) ambient conditions while wearing the Army battle dress uniform (BDU) and the MOPP-IV chemical protective ensemble. Monocular visual fields for each eye were obtained by visual perimetry at 2-hour intervals over 7 hours exposure to each ambient condition. Visual fields were significantly reduced during wearing of the MOPP-IV ensemble as compared to viewing while wearing the BDU, due primarily to the physical occlusion caused by the protective mask. Heat exposure resulted in significant but small impairments of no practical meaning. Impairments were located primarily in the lower hemisphere and the nasal areas of the visual field.

17. The performance of 24 young (mdn age = 20) male volunteers was measured on a newly developed visual vigilance task on three separate occasions; after consuming caffeine (200mg), diphenhydramine (25mg), or placebo, in a double-blind, Latin Square design. At least two days intervened between drug administrations. Caffeine use was restricted for 10 hours and smoking for 3 hours before drug administration. When compared with placebo, caffeine significantly increased the number of correct responses and decreased response times, whereas diphenhydramine decreased the number of correct responses and increased response times. Low (<100 mg/day) habitual consumers of caffeine and non-smokers had more correct responses than did high (>100 mg/day) habitual caffeine consumers and smokers, but only in the placebo condition. Non-smokers had faster response times than smokers only in the placebo condition. There were no changes in mood from pre- to post-caffeine session. However, significant increases in "depression",

"fatigue", and "confusion", and a decrease in "vigor" were found pre- and post-diphenhydramine.

18. A review and reevaluation of the validity of the Environmental Symptoms Questionnaire (ESQ) was completed. The ESQ was developed to provide a standardized procedure for assessment of symptoms experienced by individuals exposed to environmental extremes. It was used initially to delineate the symptoms of acute mountain sickness, but it has since been expanded into a more comprehensive tool for measuring subjective reactions to severe heat and cold, and to diet, physical exercise, and medications. The ESQ has also been made more reliable and user friendly by revision, addition and removal of certain items, and by compression of the initial scale values. Factor analysis of responses obtained during exposure to environmental extremes has identified several meaningful symptom clusters, and has provided the basis for developing a useful technique for scoring the questionnaire based on the item clusters. Studies utilizing the ESQ under various environmental extremes are summarized and reviewed.

19. Data collection was completed in a study of the effects of ambient heat and wearing of chemical protective clothing on performance of selected militarily relevant cognitive tasks by female soldiers. Twenty-four female soldier volunteers were first trained for two weeks on performance of the tasks. Thereafter, they completed four separate test sessions of up to 6 hours each on separate days during which they were exposed to combinations of ambient heat (91°F/61%RH) or temperate (70°F/30%RH) conditions, combined with wearing the battle dress uniform (BDU) or the chemical protective clothing ensemble (MOPP-IV). Data analysis is underway.

PUBLICATIONS:

1. Blewett, W.K., A.T. Seitzinger, D. Redmond, L. Fatkin and L.E. Banderet. Light division night decontamination operations (Technical Report No. ERDEC-TR-087). Aberdeen Proving Ground, MD: US Army Edgewood Research, Development and Engineering Center, November 1993.

2. Boudreau, E., B. Schuster, J. Sanchez, W. Novakowski, R. Johnson, D. Redmond, R. Hanson and L. Dausel. Tolerability of prophylactic Lariam® regimens, Trop. Med. Parasitology 44:257-255, 1993.

3. Fine, B.J., J.L. Kobrick, H.R. Lieberman, R.H. Riley, B. Marlowe and W.J. Tharion. Changes in human vigilance following treatments with caffeine or diphenhydramine. Psychopharmacology, (in press), 1993.

4. Johnson, R.F. and D.J. Merullo. Subjective reports of heat illness. In: Nutritional Needs in Hot Environments, B.M. Marriott (ed.), Washington, DC: National Academy Press, 277-293, 1993.

5. Kobrick, J.L., J.B. Sampson and R.F. Johnson. The Environmental Symptoms Questionnaire: Assessing reactions to environmental extremes in military operations. In: Support of Air Operations Under Extreme Hot and Cold Weather Operations. AGARD Conference Proceedings 540. Neuilly sur Seine, France: Advisory Group for Aerospace Research and Development, North Atlantic Treaty Organization, 31-1 to 31-8, 1993.

6. Levy, A., S. Dachir, T. Kadar, B. Shukitt-Hale, M.A. Stillman, and H.R. Lieberman. Nimodipine, stress and central cholinergic function. In: Calcium Antagonists in the CNS, A. Scriabine, R.A. Janis & D.J. Triggle (eds.), Branford, Connecticut: Neva Press, pp. 223-229, 1993.

7. Lieberman, H.R. Tyrosine and stress: Human and Animal studies. In: Proceedings National Academy of Science Symposia (In press).

8. Lieberman, H.R., B.J. Fine, J.L. Kobrick and J.D.E. Gabrieli. Effects of caffeine on mental performance and mood: Implications for Aircrew members. In: Nutrition, Metabolic Disorders London: SPS Ltd, pp. 30-1 to 30-10, April 1993.

9. Lieberman, HR., M.Z. Mays and K.S.K. Chinn. Effects of Wearing the M40 Mask while Sleeping. DPG/JCP-93/018. U.S. Army Dugway Proving Ground, Dugway, UT 84022, 1993.

10. Lieberman, H.R., M.Z. Mays, B. Shukitt-Hale, B. Marlowe, D. Welch and W. Tharion. Sleep in the M40 mask: Sleep quality, mask fit factor and next day performance. Proceeding of the Medical Defense Bioscience Review, Vol. II, 637-647, 1993.

11. Meiselman, H.L. and H.R. Lieberman. Mood and Performance Foods. In: Functional Foods I. Goldberg (ed.), Van Nostrand Reinhold (in press).

12. Sampson, J.B., J.L. Kobrick and R.F. Johnson. The Environmental Symptoms Questionnaire (ESQ): Development and application. Technical Report NATICK/TR-93/026, 1993.

13. Sampson, J.B., J.L. Kobrick and R.F. Johnson. Measurement of subjective reactions to extreme environments: The Environmental Symptoms Questionnaire. Military Psychology (in press).

14. Shukitt-Hale, B., M.J. Stillman, A. Levy, J.A. Devine and H.R. Lieberman. Nimodipine prevents the in vivo decrease in hippocampal extracellular acetylcholine produced by hypobaric hypoxia. Brain Res. 621:291-295, 1993.

15. Stillman, M.J., B. Shukitt-Hale, R.M. Kong, A. Levy and H.R. Lieberman. Elevation of hippocampal acetylcholine levels in conscious, unrestrained rats via a muscarinic type-2 antagonist. Brain Res. Bull. 32:385-389, 1993.

16. Tharion, W.J., J.L. Kobrick, H.R. Lieberman and B.J. Fine. Effects of caffeine and diphenhydramine on auditory evoked cortical potentials. Percept. Mot. Skills 76:707-715, 1993.

ABSTRACTS:

17. Boudreau, E., B. Schuster, J. Sanchez, R. Johnson, D. Redmond and D. Sturchler. Tolerability of a mefloquine (Lariam®) loading dose and double blind comparison with chloroquine. Proceedings of the Third Conference on International Travel Medicine 3:140, 1993.

18. Lieberman, H.R. Pharmacological and nutritional strategies to sustain performance. DOD-HFE Technical Group Minutes L-3, 1993.

19. Luo, S., E.T.S. Li and H.R. Lieberman. Tyrosine increases hypothermia-induced norepinephrine (NE) release in rat hippocampus assessed by in vivo microdialysis, Soc. Neurosci. Abstr. 19:1452, 1993.

20. Shukitt-Hale, B., M.J. Stillman, B.E. Marlowe, D.I. Welch, J.A. Devine, R.L. Galli, A. Levy and H.R. Lieberman. Hypobaric hypoxia impairs spatial memory in an exposure-dependent fashion. Soc. Neurosci. Abstr. 19:363, 1993.

21. Stillman, M.J., B. Shukitt-Hale, A. Levy and H.R. Lieberman. Cold stress exposure alters hippocampal cholinergic neurotransmission. Soc. Neurosci. Abstr. 19:1451, 1993.

PRESENTATIONS:

22. Boudreau, E., B. Schuster, J. Sanchez, R. Johnson, D. Redmond and D. Sturchler. Tolerability of a mefloquine (Lariam®) loading dose and double blind comparison with chloroquine. Third Conference on International Travel Medicine, Paris, France, 27 April 1993.

23. Johnson, R.F., J.J. Knapik and D.J. Merullo. Symptoma-tology during load carriage: Effects of pack type and load during a 20 km road march. Human Factors and Ergonomics Society, Seattle, WA, 14 October 1993.

24. Kobrick, J.L. The Environmental Symptoms Questionnaire: Assessing reactions to environmental extremes in military operations. AGARD Aerospace Medical Panel Symposium, Victoria, British Columbia, Canada, 17-19 May 1993.

25. Kobrick, J.L., J.B. Sampson and R.F. Johnson. The Environmental Symptoms Questionnaire: Assessing reactions to environmental extremes in military operations. Paper presented to the Aerospace Medical Panel, NATO Advisory

Group for Aerospace Research and Development, Victoria, British Columbia, Canada: 19 May 1993.

26. Lieberman, H.R. Effects of acute environmental stress on neurotransmission and behavior: Treatment strategies. Tri-service review of Basic Research in Stress and Performance. April 1993.

27. Lieberman, H.R. Sleep in the M40 mask: Sleep quality, mask fit factor and next day performance. Medical Defense Bioscience Review, Baltimore, MD, May 1993.

28. Lieberman, H.R. Applications of activity monitoring. New York Academy of Sciences, New York, NY, October 1993.

29. Lieberman, H.R. Psychopharmacologic strategies to alter reactivity during psychophysiological detection of deception. DoD Polygraph Institute, Ft. McClellan, AL, December 1993.

KEY BRIEFINGS:

30. Richard F. Johnson, Ph.D. Symptomatology during load carriage: Effects of pack type and load during a 20 km road march. US Army Research Institute of Environmental Medicine, Natick, MA, February 1993.

31. Richard F. Johnson, Ph.D. Military performance and neuroscience: Overview of programs and findings. Briefing presented to General Paul Borredon (French Representative to NATO Panel VIII on Defence Applications of Human and Biomedical Sciences). US Army Research Institute of Environmental Medicine, Natick, MA, April 1993.

32. Harris R. Lieberman, Ph.D. Results of melatonin research study and coordinate plans for future studies. Special Forces Medical Officer, U.S. Army Aeromedical Research Laboratory, Ft. Rucker, AL, August 1993.

SIGNIFICANT TDY:

Louis E. Banderet, Ph.D. Attended the DARPA Spoken Language and Applications Day at the National Academy of Sciences, Washington, DC, 13 April 1993.

Richard F. Johnson, Ph.D. Attended and completed training course in "Simulation Modeling for Decision Making," Arlington, VA, 16-19 March 1993.

Harold E. Modrow, Ph.D., MAJ, MS. attended AMC Acting Inspector General Course and was certified USARIEM Acting IG, AMC Headquarters, Alexandria, VA, September 1993.

Harris R. Lieberman, Ph.D. Coordinate melatonin research project with Special Forces Unit. Ft. Campbell, KY, March 1993.

Harris R. Lieberman, Ph.D. Conduct melatonin research with Special Forces Unit. Ft. Campbell, KY, April-May 1993.

Harris R. Lieberman, Ph.D. Review basic and applied Nutrition/Neuroscience Research. Pennington Biomedical Research Center, Baton Rouge, LA, August 1993.

Harris R. Lieberman, Ph.D. Coordinate plans for future melatonin research studies. U.S. Army Aeromedical Research Laboratory, Ft. Rucker, AL, December 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Louis E. Banderet, Ph.D. Senior Lecturer in Psychology, Northeastern University & Quinsigamond Community College; Co-Editor, special issue of Military Psychology (concerned with the effects of the Chemical Protective Ensemble); Reviewer, Aviation, Space, and Environmental Medicine; Reviewer, U.S. Army Field Manuals and Technical Manuals; Recommended for, Who's Who in the East 1995-96; Originator of idea for funded SBIR project; Member, Performance Enhancing Rations Committee for Tyrosine; Member, P2NBC2 Psychological Assessment Advisory Panel.

Richard F. Johnson, Ph.D. Member, Quality Assurance Committee. Past-President, Natick Chapter of Sigma Xi, The Scientific Research Society. Senior Lecturer in Psychology, Northeastern University. Guest Reviewer, Armed Forces & Society; Human Factors and Ergonomics; Journal of Aging and Health; Psychosomatic Medicine.

John L. Kobrick, Ph.D. Reviewer: Aviation, Space and Environmental Medicine; Human Factors; Military Psychology; Perceptual and Motor Skills.

Harris R. Lieberman, Ph.D. Chairman, Tyrosine Sub-committee Performance Enhancing Ration Component Program, Member Scientific Review Committee, USARIEM, Visiting Scientist, Massachusetts Institute of Technology, Special Service Appointment, Graduate School, Boston University, Served on Department of Veterans Affairs Merit Review Board in Neurobiology, Ad Hoc Reviewer for the following scientific journals: Physiology and Behavior; Psychopharmacology; Biological Psychiatry; Brain Research Bulletin. Reviewer: Louisiana Board of Regents.

A USARIEM psychologist reviewed final drafts of two publications sponsored by the U.S. Army Medical Department Center and School: FM 22-51, Leader's Manual for Combat Stress Control, and FM 8-51, Combat Stress Control in a Theater of Operations. (FM 22-51 evolved from a coordinating draft of the latter document which was reviewed by USARIEM psychologists in 1990). These manuals describe the complex characteristics, context, and exceptional challenges of modern warfare. They also prescribe thoughtful holistic strategies which should increase the fighting capabilities of the soldier and minimize combat stress.

USARIEM
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OCCUPATIONAL MEDICINE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Ankle braces have been shown to be effective in reducing ankle sprains in a variety of intercollegiate sports. We hypothesized that an outside the boot ankle brace would be equally effective in reducing ankle sprains in the military parachutist. Two prospective, randomized trials of an outside-the-boot were conducted. In the 1992 trial, 777 novice jumpers from the US Army Airborne School at Ft. Benning, GA. participated. In this randomized trial, ankle sprains were reduced 6:1 in the brace group. To see if similar benefits would be achieved in operational units with experienced jumpers parachuting under tactical conditions of darkness, carrying full combat loads, and performing mass exits, we conducted a second randomized trial with the 82nd Airborne Division, Ft Bragg, NC. In the second trial, 571 soldier volunteers participated during two mass tactical jumps. Preliminary results indicated an 18.4% incidence of overall injuries (105 injuries/571 jumpers) in bad windy weather. Of these injuries, 18.1% were ankle sprains or fractures, 11 were in non-brace wearers, 2 were in brace wearers. The risk ratio for ankle sprains for the non-brace group versus the brace group was 5.9:1, p=.02. The results of these prevention trials indicate that the incidence of ankle sprains can be significantly reduced in both training and operational parachuting by the use of an outside-the-boot ankle brace. Since completion of the first phase of the study, the Airborne School has purchased and begun outfitting all students with braces. So far, data has been collected on the first 9 classes that have worn the braces (22,000 jumps) and they have reported a 52% reduction in ankle sprains and an 80% reduction in ankle fractures. These results indicate that simple low-cost interventions can dramatically impact upon pain and disability for the individual soldier; may improve airborne school graduation rates; and perhaps most importantly, may greatly enhance overall mission effectiveness.

2. Road marching while carrying loads is a critical task required of all soldiers. Loads carried tend to be very heavy and distribution of the loads may be an important factor influencing the soldier's military effectiveness and risks of injury. To examine the influence of load and its distribution and road marching itself on critical tasks, a study was conducted on Special Forces soldiers performing six strenuous experimental 20 km road marches. The ALICE pack with frame and an experimental double-pack system with 50% load distributed in the front were tested with three loads. All marches were maximal effort. Heart rates were monitored during the marches. Before and after each march, soldiers completed the Pain Soreness and Discomfort Questionnaire (PSD, Knapik, 1990) and the Environmental Symptoms Questionnaire (ESQ, Sampson, 1993). Also, soldiers performed the following series of tasks, 1) marksmanship, 2) grenade throw, 3) strength tests, 4) synthetic works tasks, and 5) obstacle course before and after each march. A foot injury screen of all soldiers was also conducted at the end of each march. Energy expenditure was lower with the double-pack and there were less low back complaints and a lower incidence of foot blisters with heavier loads. However, more neck and hip complaints and heat illness symptoms were reported with the double-pack. Neither load nor load distribution affected cognitive ability and performance of some common military tasks. Previous road march studies indicate that when soldiers perform a strenuous road march with a heavy load, there will be significant performance decrements accompanied by increased musculoskeletal complaints and foot blisters that may impact on military effectiveness. Results of this study imply that changes in the pack design such as the double-pack system may decrease physiological stresses and reduce some musculoskeletal complaints associated with strenuous marching. Also, strenuous marches adversely influence some critical military tasks regardless of load (up to 61 kg) and distribution.

3. Cold weather injuries incurred during short term high intensity military operations are important because these operations are often critical to military success. Identification of modifiable risk factors and investigative work on preventive strategies could have high returns in

terms of injury reduction, thus keeping soldiers in action. Prior epidemiologic studies have examined infantry soldiers training in both cold and warm seasons but not during short, intense operations only in the cold. Also, there are only a few systematic studies identifying risk factors for cold weather injuries. A USARIEM cold weather study has been in progress. A study was recently conducted with a marine battalion (N=461) at the Marine Corps Mountain Warfare Training Center (MCMWTC), Bridgeport, CA, using both descriptive and experimental approaches. The descriptive portion of the study involved conducting injury and illness surveillance procedures during cold weather marine field training. Preliminary results showed a cold injury rate of 2.0% which is similar to reports from infantry training at Ft. Drum, NY. The experimental approach of the study was to test a prototype sock system consisting of an inner polyester sock liner with an outer thick, dense, prototype sock (50% wool, 50% polypropylene). The hypothesis was that the sock system would reduce cold injuries (i.e. trenchfoot, frostbite, etc.) and other injuries (i.e. blisters, hot spots, etc.) related to cold weather training. A past USARIEM study tested this sock system in a warm training environment at Parris Island, SC and found the sock system to significantly reduce blisters in marine recruits. Cold weather injury and illness surveillance and testing of the sock system are to continue in Alaska with the same test population studied at the MCMWTC. Data entry and analysis from the MCMWTC portion of the study is in progress.

4. Musculoskeletal training-related injuries are the leading cause of medical clinic visits among Army trainees. Therefore epidemiologic analyses were conducted were conducted for a series of prospective studies. The purpose of this series of studies was to determine the incidence, types and risk factors for injuries occurring during Army initial entry training. It was hypothesized that: 1) greater amounts of weight bearing training, such as running and marching, would result in higher injury rates; and 2) trainees exhibiting lower levels of physical fitness would be at greater risk for injuries. This series of studies utilized a prospective, follow-up study methodology to: 1) determine the incidence of injuries and 2) identify risk

factors and hazardous training exposures among army trainees. Three studies conducted at Ft Jackson and Ft Benning from 1984 to 1989 followed 2,604 trainees (1498 men and 1106 women) over the course of basic training. Baseline evaluations included: 1) demographic characteristics, past physical activity levels, prior occupational experience, and medical histories and 2) measurements of height, weight, percent body fat, anatomic factors (i.e. arch height of the foot, leg lengths) and physical fitness (endurance, strength, flexibility). Follow-up consisted of: 1) documentation of unit training and 2) complete documentation of all injuries occurring to trainees during the study. Recent analyses have focused on multivariate modeling. Results indicate: Men training in units that do more running are more likely to experience injuries (30% more injuries among those running 10 miles per week compared to those running 6 miles per week. The cumulative incidence of women experiencing one or more injuries during Army basic combat training is roughly twice as high as for men, approximately 25 injuries/100 trainees/month versus 12 injuries/100/month. Risk factors among women include only low levels of endurance (slow run times) and short stature, while documented risk factors for men include older age, smoking cigarettes, previous injuries, low levels of past physical activity, high arched feet, both high and low degrees of flexibility, and low levels of physical fitness on entry to the Army. These data indicate that injuries cause significant amounts of morbidity among male and female Army trainees. Identification of a number of potentially modifiable risk factors for injuries suggests that strategies to prevent training-related injuries can be devised. Our key finding suggests that reductions in the amount of running may prevent injuries without adversely affecting physical fitness. A number of other modifiable risk factors, such as low levels of fitness and smoking, were identified and could be used to devise prevention strategies. Also, some of the non-modifiable risk factors, such as older age and arch height might be important factors to screen for in selecting and training individuals for specific tasks and missions.

5. Previous studies of basic training indicate that the incidence of injury among women is higher than for men. However, it is also well documented that women enter the Army with lower levels of physical fitness, performing fewer push ups and sit ups and running slower times than male trainees. It was therefore hypothesized that low levels physical fitness might be the primary risk factor for injury rather than gender per se. For this reason, multivariate analyses (stratified chi squares and logistic regression) were conducted to specifically control for the confounding association of gender with physical fitness. For methods of data collection see previous accomplishment. The results of multivariate analyses indicate that when the association of gender with physical fitness is controlled for the relative risks of injury for women compared to men are no longer significant, declining from about two to a little over one. Furthermore, when such models are constructed using forward or backward stepping analytical techniques, gender does not enter any of the models if aerobic fitness (run times) is included as a factor. These analyses indicate that women and men of similar fitness levels can be expected to experience the same risks of injury. The results further imply that concern that female soldiers may more likely be injured while performing vigorous physical tasks is unwarranted, provided they exhibit the requisite fitness to carry out the tasks. Also, these results suggest that training injuries to female soldiers may be prevented by enhancing their level of physical fitness.

6. Studies indicate that a significant proportion of basic trainees report to sick call for an illness or musculoskeletal injury during a two month basic training cycle. Furthermore, women trainees appear to have more sick call visits than men. This increased incidence of illness or injury has been attributed to low levels of physical fitness rather than gender per se. In order to further understand the incidence, types and risk factors for illness and injury in female basic trainees, a descriptive study was conducted at Ft. Jackson in the spring of 1993. One hundred and sixty five females were followed during one basic training cycle lasting two months. The cumulative incidence in these female basic

trainees was 67% for one or more injuries and 57% for one or more illnesses resulting in 1273 and 141 days lost to training, respectively. The rate of injury was 33 per 100 trainees per month. Eighty nine percent of the injuries resulted in time-loss from duty. Seventy four percent of all injuries were caused from overuse and most involved the lower extremities (78%). Risk factors for injury among women included: self report alcohol use ($p=0.021$), low levels of aerobic endurance (slow run times, $p=.01$), weak lower body and low back strength (measured by an incremental dead lift, $p=.046$) and low anaerobic power and strength (measured by the load carry, $p=.002$). These data suggest that injuries cause a significant amount of morbidity among female basic trainees. Modifiable risk factors that include low fitness levels and increased alcohol consumption were identified and could be used to develop interventions to reduce injury in future trainees.

7. Previous studies of initial entry and infantry training show that musculoskeletal injuries resulting from physical and operational training are a serious cause of morbidity in terms of time lost from duty. There is no valid injury data on highly trained soldiers such as the special forces. We studied one hundred sixty-two special forces soldiers over a one year period. Age, height, weight and Army Physical Fitness Test scores were obtained from the unit's training office. We documented training-related musculoskeletal injuries occurring during this period and causes of injury by a complete review of every participant's medical record. Data indicate that special forces soldiers are older, taller and heavier than U.S. Army averages. However, they are highly fit (i.e. APFT scores) when compared with other Army populations of the same age. Injury rates are considerably lower in the special forces soldiers when compared to infantry soldiers (6.8% vs 13.3%). Ankle sprains (16.4%) and low back injuries (16.4%) were the most common injuries documented in these special forces soldiers followed by knee sprain/strain (14.8%), generalized musculoskeletal pain (9.8%), and fractures (6.6%). The most common mechanism of injury was running (13.1%), followed by recreational sports (8.2%), parachuting (6.6%), weight training (6.6%), rucksack marching (3.3%), skiing (3.3%), and calisthenics

(3.3%). Results of chi square tests for association between intrinsic (age, height, weight, body mass index) and extrinsic factors (pushups, situps, 2 mile run time) and risk of injury showed no significant associations. However, there was a trend for slower run times to be associated with more injuries. These data indicate that special forces soldiers are a highly fit group. Also, injury incidence is lower when compared to infantry soldiers. However, the injuries are more severe (i.e. time-loss) which might be attributed to more rigorous training and high risk activities required to accomplish their mission. Even though not significant, there is a trend for less aerobically fit special forces soldiers to have more injuries. Also, running, sports and parachuting appear to be high risk activities which deserve further focus as far as preventive strategies.

8. Combat Engineers engage in heavy construction activities but like other operational units, also perform rigorous weight bearing physical activities such as running and marching. We studied associations between training-related injuries and physical fitness over a one year period in 147 male combat engineers. Incidence of new musculoskeletal injuries was documented by a complete review of each soldier's medical record. Physical fitness was measured by the standard Army Physical Fitness Test (i.e. pushups, situps, 2- mile run time). Sixty-eight percent of the soldiers suffered one or more training injuries. Soldiers performed an average (±SD) 61± 13 pushups, 65±11 situps and ran an average time of 14.6±1.3 min. Results for chi square tests for association of fitness (i.e. pushups, situps, run time) and risk of injury showed that those with slower run times to be at a significantly higher risk for injury ($p=0.03$). No associations for pushups and situps and risk of injury were documented. These data indicate that injury incidence among combat engineers is slightly higher than reported in infantry soldiers. Also, the run times among the combat engineers are slightly slower. Perhaps lower levels of physical fitness may be the explanation for higher injury incidence among combat engineers.

9. Tests to measure the various components of physical fitness can be time-consuming and impractical when studying large populations. The purpose of this study was to determine if self reported assessments of physical fitness accurately reflect fitness in soldiers. Two groups of male infantry soldiers (n=96 and n=276) and one group of older male military officers (n=241) completed a simple questionnaire that asked for subjective assessments of various components of physical fitness. Specifically, they were asked to rate the following as compared to others of the same age and sex: 1) endurance, 2) sprint speed, 3)strength, and 4) flexibility. A five-point scale was used. After administering the questionnaire, the following fitness components were measured, 1) $\dot{V}o_2max.$, peak VO_2, two mile run time, 2) Wingate test, upper body power, pushups, situps, 3) upper and lower body strength (1RM), and 4) flexibility tests. The self-assessed fitness ratings were significantly related to aerobic capacity, strength, and hip/lower back flexibility. This simple questionnaire may be a practical method for estimating and categorizing individuals into fitness levels. The summary (DD Form 1498) for work unit 128 lists the progress and publications resulting from this study. This is the first study to show the relationship between subjective and objective measures of aerobic fitness, strength, and hip/low back flexibility. Our results imply that in physically active populations, a simple self-rating questionnaire may be useful in epidemiologic studies where investigators need estimates of physical fitness but are unable to obtain them by other methods. Also, through the use of this tool for categorizing individuals into fitness levels, it may be useful in evaluating relationships between fitness components and injury and illness.

10. Personnel from the U.S. Army Physical Fitness School collected data from soldiers, representative of the age and gender for Army personnel within Conus. Data were collected at 14 U.S. Army installations by local Army Physical Fitness cadre and personnel from the Physical Fitness School. This effort analyzes these data statistically and provides norms for each age grouping specified for the physical fitness test and norms for male and female soldiers. For each fitness event, norms are

provided for raw scores and point scores; norms are also provided for total points. Several examples are provided to illustrate how the norms may be used and the procedures to find percentiles in the tables. These norms permit comparisons of individual soldiers or units to other soldiers in the United States. Norms are specified in terms of percentiles which facilitates understanding and description of a soldier's (unit's) physical fitness in terms of other soldiers in the U.S. Army.

11. The metabolic cost of locomotion (E_l) is proportional to the ratio of body mass (m_b) to the amount of time the foot is in contact with the ground (t_c) (Kram, Nature 346:265-267, 1990). Knowing this relationship, we previously developed a portable electronic foot contact monitor and used this monitor to derive and validate an equation to estimate E_l from t_c and m_b. Cross-validation showed the estimated E_l to be highly correlated with the measured E_l ($r=0.99$). These studies were done with soldiers walking and running in physical training (PT) outfits on a treadmill. In a follow-up study we tested 7 soldiers in battle dress uniform (BDU) while carrying 4 different loads (0, 20, 30 and 40 kg) at 5 different speeds (2.0, 2.5, 3.0, 3.5 and 4.0 miles/hr). Energy cost (E_l) was measured by indirect calorimetry with resting energy expenditure subtracted out. When the results are analyzed we will be able to determine how the load carried by the soldier influences the relationship between energy cost and foot contact time. This study is an important step in moving the contact device from the laboratory to the field. Weight bearing physical activity has been shown to be an important risk factor for training-related injuries. With further development this device could provide a valid means of estimating the amount of physical activity performed by soldiers during typical military operations. Researchers lack detailed information about the intensity and duration of exercise during military field operations. Consequently, the carbohydrate, protein, and fat requirements of soldiers engaged in military tasks cannot be accurately calculated. Without an appropriate supply of dietary carbohydrates, the physical performance of soldiers will deteriorate. The foot contact monitor can provide the detailed information about the duration and intensity of

exercise needed to accurately calculate the macronutrient requirements of soldiers. Nutritional strategies can be developed to meet the specific nutritional needs of soldiers.

12. Eccentric exercise is known to cause muscle tissue damage and pain. A study was conducted to determine the effect of road marching with loads on leg strength and indicators of muscle tissue damage - creatinine kinase (CK). Under field conditions, changes in leg strength and CK after two successive maximum effort 20 km road marches performed by 9 Special Forces soldiers was evaluated. Leg strength was significantly reduced following both road marches. Also, CK was elevated in all subjects following the first road march, but was more elevated among those carrying heavier loads after the second march. A second study was conducted under laboratory conditions evaluating eccentric cycle exercise. This study documented not only the effects on leg strength and muscle tissue, but also the degree of adaptive responses. Seven male volunteers were followed for 28 days. They performed 4 successive bouts of eccentric bicycle exercise separated by one week of rest. Knee extension strength and CK were measured at baseline and after each exercise bout. Following the first eccentric exercise bout leg strength declined and did not return to baseline for 4 days. However, after bouts 2 to 4 strength decreased less immediately post exercise and returned to baseline within one day. CK was elevated one day after the first eccentric bout and remained above baseline for 8 days. Once CK returned to baseline it was not effected by subsequent bouts of exercise. The eccentric component of road marching and other strenuous activities causes muscle tissue damage and decrements in muscle strength. However, what is important to the soldier who undergoes regular exercise that contains an eccentric component that muscles rapidly adapt to eccentric exercise decreasing the adverse effects. The similarity of responses to road marching and eccentric bicycling suggest that laboratory models can be utilized to establish general principles of performance effects, tissue damage, and injury causation. Laboratory studies such as the eccentric bicycling study provide helpful guidance for future

research and suggest possible training strategies to enhance physical performance and decrease injury rates.

13. Magnetic resonance imaging has been shown to be of great value in diagnosing musculoskeletal injuries and for studying the structure and anatomy of tissues. In order to develop the technical capabilities for using this technique for studying changes in and injuries to musculoskeletal structures associated with physical training and military operations a study was conducted to: 1) examine the relationship of thigh muscle cross sectional area using magnetic resonance imaging (MRI) techniques and muscle strength among men and women, and 2) develop the skills required to study limb anatomy using MRI. Thigh muscle area was determined by MRI in 9 male and 9 female volunteers. Muscle area of the right knee extensors was calculated using computerized planimetry after portioning out femur and subcutaneous fat areas. Test-retest reliability of MRI assessed muscle area was 0.96 ($p < 0.001$). Isokinetic peak torque of knee extensors was measured on a Cybex II ergometer at two different speeds. Also, one repetition maximum knee extensor strength was measured on a Universal device. Results indicated moderate correlations of muscle area with isokinetic strength for men and women, and strong correlation with maximum strength only for men. Results of this study indicate that MRI techniques can be employed to quantitatively study associations between musculoskeletal anatomy and physical performance. In the future these techniques show promise for examination of the relationship between anatomy, physical performance, and also injury. The advantage of MRI for the study of injury is that it provides a non-invasive method of documenting even subclinical tissue changes and damage.

14. Previous research has shown that it is possible to study the intake and/or use of carbohydrates by monitoring the natural abundance of ^{13}Carbon (^{13}C) on the glucose molecule. Our purpose was to develop a nuclear magnetic resonance spectroscopy coil that could detect ^{13}C in the soldier's liver and muscle. A radio frequency coil was built consisting of a ^{13}C detector, ^{1}Hydrogen (^{1}H) decoupler and amplifiers. The detector consisted of a radio

frequency transmitter/receiver that directed radio pulses into the tissue, and picked up radio frequency pulses reflected back from the tissues. The ^{1}H decoupler eliminated energy sources that interfered with the detection of the ^{13}C signal. The amplifiers magnified the received ^{13}C signal so it could be detected with available instruments. Our objectives were to interface the coil to a large static magnet and validate that it can detect known amounts of ^{13}C-glucose. Soldiers are often required to perform prolonged physical activity that can deplete their energy stores. One critical energy source in the soldier's body is the carbohydrate reserve. Depletion or even lowering the carbohydrate stores below a certain critical level can result in premature fatigue. Further, there is evidence that carbohydrate depletion can result in muscle tissue damage thus making the soldier more vulnerable to injuries. Development of this device provides a method to study fatigue, muscle damage and possibly injuries and how they relate to the energy reserves of the body.

PUBLICATIONS:

1. Amoroso, P.J. Injury Prevention in Airborne Operations. In: United States Army Aviation Medicine Handbook, 3rd Edition Ft. Rucker, AL. Society of US Army Flight Surgeons. 486-487, July 1993.

2. Bielenda, C., J. Knapik and D. Wright. Physical fitness and cardiovascular disease risk factors of female senior U.S. military officers and federal employees. Military Medicine 158:177-181, 1993.

3. Cowan, D.H., B.H. Jones and J.R. Robinson. Foot morphologic characteristics and risk of exercise-related injury. Arch. Fam. Med. 2:773-777, 1993.

4. Cowan, D.H., J.R. Robinson, B.H. Jones, D.W. Polly and B.H. Berrey. Consistency of visual assessments of arch height among clinicians. Foot and Ankle Journal International (in press), 1993.

5. Jones, B.H., M.W. Bovee, J.M. Harris and D.N. Cowan. Intrinsic risk factors for exercise-related injuries among

male and female army trainees. Am. J. Sports Med. 21:705-710, 1993.

6. Jones, B.H., D.N. Cowan, J.P. Tomlinson, J.R. Robinson, D.W. Polly and P.N. Frykman. Epidemiology of injuries associated with physical training among young men in the army. Med. Sci. Sports Exerc. 25:197-203, 1993.

7. Jones, B.H., K. Reynolds, P.B. Rock and M.P. Moore. Exercise-related musculoskeletal injuries: risks, prevention and care. Chapter 31, American College of Sports Medicine Resource Manual for Guidelines on Exercise Testing and Prescription, 2nd edition, Philadelphia PA: Lea & Febiger, 378-393,1993.

8. Knapik, J.J., J. Zoltick, H.C. Rottner, J. Phillips, C. Bielenda, B. Jones and F. Drews. Relationship between self-reported physical activity and physical fitness in active men. Am. J. Preventive Med. 9:203-208, 1993.

9. Knapik, J.J., P. Ang, K. Reynolds and B.H. Jones. Physical fitness, age and injury incidence in infantry soldiers. J. Occupational Med. 6:589-603, 1993.

10. Knapik, J.J., R. Johnson, P. Ang, H. Meiselman, C. Bensel, W. Johnson, B. Flynn, W. Hanlon, J. Kirk, E. Harman, P. Frykman and B. Jones. Road march performance of Special Operations Soldiers carrying various loads and load distributions. USARIEM Technical Report No. T14-93, 1993.

11. Reynolds K.L., H.A. Heckel, C.E. Witt, J.W. Martin, J.A. Pollard, J.J. Knapik and B.H. Jones. Cigarette smoking, physical fitness and injuries in infantry soldiers. Am. J. Preventive Med. (In press), 1993.

ABSTRACTS:

12. Amoroso, P.J., N.S. Bell and B.J. Jones. Military parachuting injuries among men and women. Proceedings of the Aerospace Medical Association 65th Annual Scientific Meeting (In press).

13. Jones, B.H., M. Scully, D.A. DiBenedetto, D.A. Jezior and J.A. Pollard. Smoking, physical fitness, and injuries during army initial entry training. Med. Sci. Sports Exerc. 25:S49, 1993.

14. Kirkendall, D.T., M.A. Jones, Z. Jiang and J. Knapik. CK and PGE2 responses to repeated eccentric exercise. Med. Sci. Sports Exerc. 25:S34, 1993.

15. Knapik, J., M. Bovee, J. Staab and P. Ang. Effect of successive bouts of eccentric exercise on isokinetic strength. Med. Sci. Sports Exer. 25:S149, 1993.

16. Reynolds K.L., J. Knapik, R. Hoyt, M. Mayo, J. Bremmer and Jones B. Association of training injuries and physical fitness in U.S. Army Combat Engineers. Med. Sci. Sports Exerc. (In press), 1993.

17. Ryan, J.B., P.J. Amoroso, B.J. Jones, B.T. Bickley, P. Leitschuh and Taylor, D.C. Impact of an outside-the-boot ankle brace on sprains associated with military airborne training. Orthopedic Research Society, 40th Annual Meeting, (in press).

18. Staab, J., J. Knapik, S. Smith, D. Kuethe and L. Neuringer. The relationship between muscle strength and muscle cross sectional area determined by magnetic resonance imaging. Med. Sci. Sports Exerc. 25:S181, 1993.

PRESENTATIONS:

19. Amoroso, P.J. Military Parachuting Injuries; Retrospective and Prospective Analyses. AMEDD Professional Short Course: Current Concepts in Environmental Medicine, USARIEM, Natick, MA, 6 May 1993.

20. Amoroso, P.J. Injury Control for the U S Army: Parachute Injuries Tri-service conference in emergency medicine, San Antonio, TX, 12 May 1993.

21. Amoroso, P.J. Military Parachuting Injuries: Epidemiology, Prevention and Control. AMSUS Tidewater

chapter, Military Trauma symposium, Norfolk, VA, 3 June 1993.

22. Bell, N. and Jones, B.H. Injury risk factors among male and female Army trainees. 121st Annual Meeting of the American Public Health Association, San Francisco, CA, 24-28 October, 1993.

23. Jones, B.H. Epidemiology of Injuries in Military Populations, Office of the Surgeon General Staff Development Conference, December 1993.

24. Jones, B.H. Military Injuries Associated with Training and Operational Activities. Army Preventive Medicine Conference, Tysons Corner, VA, September 1993.

25. Jones, B.H. Surveillance and Epidemiology of Training Injuries in Military Populations. Symposium on Surveillance of Recreational and Sports Injuries, Annual meeting of the American College of Sports Medicine, Seattle, WA, June 1993.

26. Jones, B.H. Musculoskeletal Training Injuries. Environmental Medicine Course. U.S Army Research Institute of Environmental Medicine, Natick, MA May 1993.

27. Jones, B.H. Musculoskeletal Injuries Associated with Military Training: Facts and Fiction. Lecture to Medical Students, Uniformed Services University of Health Sciences, Bethesda, MD, April 1993.

28. Knapik, J.J. Physical fitness Training and Military Performance. Current Concepts in Environmental Medicine, Natick, MA, 6 May 1993.

29. Reynolds, K.L. Musculoskeletal Injuries In Military Training: Occurrence and Prevention. Lecture to the Corps of Cadets, Texas A & M University, College Station, Texas, March 1993.

30. Reynolds, K.L. Foot and Ankle Injuries in Military Training: Occurrence, Management and Prevention.

Environmental Medicine Course. US Army Research Institute of Environmental Medicine, Natick, MA, May 1993.

KEY BRIEFINGS:

31. Paul J. Amoroso, M.D., MAJ, MC. USARIEM Parachute Soft Landing System. Briefing presented to COL Jeffrey White, Director, Airborne Test Board, Ft. Bragg, NC, February 1993.

32. Paul J. Amoroso, M.D., MAJ, MC. Department of Defense Violence Prevention Programs. Briefing at the 12th meeting of the CDC Advisory committee for Injury Prevention and Control, 9-10 August 1993.

33. Paul J. Amoroso, M.D., MAJ, MC, Katy L. Reynolds, M.D., LTC, MC and David Klock, CPT, MC. Effect of an outside the boot ankle brace on the incidence of ankle and other injuries associated with military airborne operations. Briefing to COL Tony, Commander, 10th Special Forces Group, and XO LTC Heinneman, Ft Devens, MA, 3 November 1993.

34. Bruce H. Jones, M.D., LTC, MC. Update on Activities of the DoD Injury Surveillance and Prevention Work Group to Service Safety Chiefs, National Defense College, Ft. McNair, Washington, D.C., July 1993.

35. Bruce H. Jones, M.D., LTC, MC. Overview of Occupational Medicine Division Research, Research Area Directorate III Program Analysis and Review, Army Research Institute of Environmental Medicine, Natick, MA, October 1993.

36. Bruce H. Jones, M.D., LTC, MC. Overview of USARIEM Military Injury Research Program. Armed Services Biomedical Research Evaluation and Management Joint Services Technical Coordinating Group - 5. Naval Health Research Center, San Diego, CA, February 1993.

37. Bruce H. Jones, M.D., LTC, MC. Overview of Occupational Medicine Division Research, Research Area Directorate III Program Analysis and Review, Army Research

Institute of Environmental Medicine, Natick, MA, February 1993.

38. Joseph J. Knapik, Ph.D., MAJ, MS. Research Initiatives Related to Individual Enhancements for Special Operations Soldiers. Special Operations Forces Research and Development Organization, Ft Bragg, NC, 13 April 1993.

39. Katy L. Reynolds, M.D., LTC, MC. Progress report on injury/illness surveillance study of special forces soldiers. Col. Toney, Commander, 10th Special Forces; LTC Kirschner, Executive Officer, 10th Special Forces, April 1993.

SIGNIFICANT TDY:

Paul J. Amoroso, M.D., MAJ, MC. Site visit to the Aircast Corporation to meet with COL Larry White, Commander 11th Infantry Regiment, USAIS, Ft. Benning, GA and Aircast staff to discuss introduction of ankle braces to the Airborne School, Summit, NJ, 9 February 1993.

Paul J. Amoroso, M.D., MAJ, MC, and staff of twelve. To conduct phase two of the study "Effect of an outside the boot ankle brace on the incidence of ankle and other injuries associated with military airborne operations." Ft. Bragg, NC, 18-26 February 1993.

Paul J. Amoroso, M.D., MAJ, MC, Joseph Knapik, MAJ, MS, and Jon Pollard, SGT. To complete medical records review as part of phase two of the study "Effect of an outside-the-boot ankle brace on the incidence of ankle and other injuries associated with military airborne operations." Ft. Bragg, NC, 21 March - 1 April 1993.

Paul J. Amoroso, M.D., MAJ, MC. To attend the 2nd Meeting of the DoD Work Group on Injury Surveillance and Prevention, 13-14 April 1993.

Paul J. Amoroso, M.D., MAJ, MC. To attend the Short Course on Injury Epidemiology, Atlanta, GA, 16-18 May 1993.

Paul J. Amoroso, M.D., MAJ, MC. To Attend the 3rd World Conference on Injury Prevention and Control, Atlanta, GA, 19-23 May 1993.

Paul J. Amoroso, M.D., MAJ, MC. To attend the Aerospace Medical Association Meeting, Toronto, Canada, 24-28 May 1993.

Paul J. Amoroso, M.D., MAJ, MC. To attend the 3rd Meeting of the DoD Work Group on Injury Surveillance and Prevention, Washington, DC, 30 June 1993.

Paul J. Amoroso, M.D., MAJ, MC. To attend the Preventive Medicine Officers' Symposium, Tyson's Corner, VA, 19-24 September.

Paul J. Amoroso, M.D., MAJ, MC. To attend the Army Safety Management Information Systems (ASMIS) course, US Army Safety Center, Ft Rucker, AL, 14-19 November 1993.

Paul J. Amoroso, M.D., MAJ, MC, Joseph Dettori, LTC, MS. To attend the 4th Meeting of the DoD Work Group on Injury Surveillance and Prevention, 7-8 December 1993.

Paul J. Amoroso, M.D., MAJ, MC, and Bruce H. Jones, M.D., LTC, MC. Site visit at the Army Casualty Office, Alexandria, VA, 21 September 1993.

Paul J. Amoroso, M.D., MAJ, MC, Joseph Dettori, LTC, MS, and Kathleen Westphal, LTC, MS. Site visit Army Disability Agency, Forest Glenn Annex, WRAMC, Washington, DC, 9 December 1993.

Bruce H. Jones, M.D., LTC, MC. Chairman DoD Injury Surveillance and Prevention Work Group, Pentagon, Washington, D.C., December 1993.

Bruce H. Jones, M.D., LTC, MC. DoD Representative to Civilian External Peer Review of DoD Pediatric Emergency Care Work Group, Washington, D.C. July 1993.

Bruce H. Jones, M.D., LTC, MC. Chairman DoD Injury Surveillance and Prevention Work Group, Pentagon, Washington, D.C., June 1993.

Bruce H. Jones, M.D., LTC, MC. DoD Representative to Department of Health and Human Services Advisory Committee for Injury Prevention and Control, Centers for Disease Control, Atlanta, GA, March 1993.

Katy L. Reynolds, M.D., LTC, MC. Conduct injury/illness surveillance study of combat engineers, Ft Drum, NY, June 1993.

Katy L. Reynolds, M.D., LTC, MC. Conduct initial injury/illness surveillance study of marines before start of cold weather training study, Camp Lejeune, NC, January 1994.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Jones, Bruce H., M.D., LTC, MC, Division Chief. Chairman, DoD Injury Surveillance and Prevention Work Group; DoD Representative to Department of Health and Human Services, Centers for Disease Control Advisory Committee for Injury Prevention and Control; DoD Representative Civilian External Peer Review Program Work Group for Pediatric Emergency Care; Participant, National Center for Health Statistics, International Collaborative Effort for Injury Control; Coordinator, Occupational Injury Research, Armed Services Biomedical Research Evaluation and Management Joint Technical Coordinating Group - 5; Guest Reviewer: Clinical Journal of Sports Medicine, Physician and Sportsmedicine; Fellow, American College of Preventive Medicine and American College of Sports Medicine; Member, American Medical Association, Association of Military Surgeons of the United States, and the American Public Health Association.

Amoroso, Paul J., M.D., MAJ, MC. Associate Fellow, Aerospace Medical Association (ASMA). Member, American Public Health Association. Member, Association of Military Surgeons of the U.S. Member, Massachusetts Medical

Society. Member, National Association of Public Health Policy. Member, Society of US Army Flight Surgeons.

Joseph Dettori, LTC, MS. Assistant Chief, AMSC Regional Clinical Investigation and Research.

Reynolds, Katy L., M.D., LTC, MC. Member, American College of Physicians, American College of Sports Medicine.

OCCUPATIONAL PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. An increased understanding of the biomechanics of load carriage can lead to injury reduction and enhanced performance through physical training, improvements in equipment, technique, or personnel selection. To examine the effects of load carriage on gait kinematics, 16 physically fit males were each filmed from the right side while carrying backpacks of 6, 20, 33, and 47 kg in balanced order. Walking speed (4.7 km/hr) was regulated by a visual cuing device. Digitized coordinates were used to determine body kinematics throughout the stride, including those of the body center of mass (CM). Significant ($p<.05$) findings included: stride frequency did not differ among the first 3 loads, but was higher for the heaviest load. Increasing load caused greater forward trunk lean throughout the gait cycle, which accounted in large part for decreases in both minimum and maximum CM height. Trunk sway increased 22% from the lightest to heaviest load. Increase in load did not affect the forward swing of the arms, but reduced the rearward swing by 60%, resulting in a 33% drop in shoulder range of motion. Ankle range of motion was not affected by load, while degree of knee bend increased with load. In conclusion, several changes in gait occur with increasing load; some may represent direct mechanical effects of the load, while others may serve to control load-induced increases in muscular work as well as stress and strain on muscle, bone, and other tissues.

2. Enhanced understanding of the effects of speed on the biomechanics of load carriage could lead to the development of various innovations for lessening medical risk and improving performance. To examine the effects of walking speed on load carriage kinematics, 16 fit males, each carrying a loaded backpack (26.5 kg), were filmed at 60 Hz while walking at speeds of 1.1, 1.3, and 1.5 m/s. Digitized film coordinates were used to determine body kinematics, including movement of the center of mass (CM). Significant findings ($p<.05$) were: both stride length and frequency increased by about 7% for each 0.2 m/s increment in walking speed. Both min and max horizontal CM velocities increased with walking speed. Inclination of the trunk was not affected by walking speed; neither was ankle range of motion. Degree of knee flexion after heelstrike increased with walking speed, as did the degree to which the hip was both extended and flexed. Hip range of motion increased by 4 degrees (8%) as walking speed increased from 1.1 to 1.5 m/s. Arm swing also increased by 4 degrees, a 25% change. In conclusion, increased load carriage speed is accompanied by equal percentage increases in stride frequency and stride length, lower and faster drop of the CM, faster max downward than upward CM velocity, and increased range of motion about the knee, hip, and shoulder. These specific adjustments to faster walking most likely maintain smoothness and efficiency of gait and control increase in impact forces.

3. Wearing of chemical protective (CP) clothing is known to adversely affect physical performance. However, limited quantitative data are available regarding the physiological and perceptual responses to wearing US military CP clothing during incremental steady-state exercise. Oxygen uptake (Vo_2), ventilation (V_E), heart rate (HR), rating of perceived exertion (RPE) and respiratory distress (RD) were determined in 14 male soldiers who walked on a treadmill at 1.56 m/s for 20 min, in balanced order, at grades of 0, 5, and 10% in three clothing conditions: BDU (battle dress uniform), MASK (BDU + M-17 protective mask), and CP clothing (MASK + overgarment, gloves and boots). In the BDU condition, exercise intensities expressed as $\%Vo_2max$ were 29, 42, and 59% at the three grades, respectively. Vo_2 was significantly ($p<.01$) increased at all grades (range 13

to 18%) in CP clothing compared to BDU. No differences were seen, however, in $\dot{V}O_2$ between BDU and MASK at any level of exercise. V_E was significantly higher at the two highest grades in CP clothing compared to BDU but when expressed relative to $\dot{V}O_2$ ($V_E/\dot{V}O_2$) significant hypoventilation occurred at 0% and 5% grades but not at 10%. In the MASK condition, V_E was significantly lower at the 10% grade and $V_E/\dot{V}O_2$ was significantly lower at all grades compared to BDU. Both RPE and RD were significantly higher ($p<.01$) in CP clothing compared to BDU but no differences were seen in the MASK condition. The results show that despite the hypoventilation which occurs with the mask, $\dot{V}O_2$ is not affected at exercise intensities up to 60% of $\dot{V}O_2max$. It is concluded, therefore, that the contribution of the mask to the overall physiological and perceptual strain of physical exercise in CP clothing is negligible and that the marked increase in $\dot{V}O_2$ is attributable to the weight and/or hobbling effect of the clothing.

4. Many physical tasks in military and industrial settings require the use of chemical protective (CP) clothing. Little data are available, however, regarding the physiological consequences that CP clothing places upon physical task performance. To evaluate the metabolic cost of wearing CP clothing, nine men (mean: age 19.8 yrs, body mass 79.7 kg, $\dot{V}O_2max$ 55.2 $ml \cdot kg^{-1} \cdot min^{-1}$) and eleven women (mean: 25.7 yrs, body mass 62.8 kg, $\dot{V}O_2max$ 44.8 $ml \cdot kg^{-1} \cdot min^{-1}$) performed nine occupational tasks (three load carriage, four lift and carry, two lift and lower) ranging in intensity from 10 to 80 $\%\dot{V}O_2max$. The subjects performed these tasks in two clothing conditions: battle dress uniform (BDU) and CP clothing (M-17 mask + overgarment, boots and gloves, wt=5.6 kg). Oxygen uptake ($\dot{V}O_2$) was measured using the portable Oxylog meter and heart rate was determined by the Polar Heartwatch. Seven out of nine tasks showed significant increases ($p<.05$) in $\dot{V}O_2$ (men: 5 to 14%; women: 8 to 22%) and HR (men: 7 to 14%; women 4 to 15%) in CP clothing compared to BDU for both men and women. These seven tasks required mobility across a distance, such as load carriage or lift and carry. The two stationary tasks, both lift and lower, showed no differences between

the two clothing conditions. In addition, women exercised at a higher %$\dot{V}O_2$max ($p<.05$) wearing BDU and CP clothing for all tasks. It is concluded that wearing CP clothing increased the energy cost of tasks that require mobility and that this increase places greater physiological demand on women than men.

5. The traditional method of dividing performance scores by anthropometric measures (ratio normalization), for the purpose of comparing individuals and groups, has been shown to be statistically invalid unless both the criteria of data linearity and zero intercept are met. Linear regression and exponential curve fitting have been proposed as more valid alternatives. In order to determine the validity of dividing by fat-free body mass (FFM) to compare the muscular strength scores of men and women, maximal lift capacities (MLC) of 2,601 males (23.6±6 yr, 175±7 cm, 75±11 kg; FFM = 61±7 kg) and 1,301 females (21±4 yr, 163±6 cm, 59±7 kg: FFM = 44±5 kg) were assessed with a weight-stack-simulated power clean lift. Mean±SD MLC was 61±12 kg for males and 30±6 kg for females. Best fit linear regression equations with zero intercepts, used to determine the validity of ratio normalization were: Males MLC = 1.0(FFM); Females MLC = 0.69(FFM). Best fit linear regression equations with non-zero intercepts were: Males MLC = 1.1(FFM)-3.9; Females MLC = 0.59(FFM)+4.2. The best fit exponential functions were: Males MLC = $0.67(FFM)^{1.1}$; Females MLC = $1.16(FFM)^{0.86}$. Statistical analysis of predicted strength using all three sets of equations showed significantly lower strength per kg FFM for females than males. All three sets of equations produced multiple Rs of 0.63-0.65 for men and 0.43-0.45 for women, and very similar mean errors of prediction (≈13%). The reasons ratio normalization proved equal to the other methods was that data curvilinearity was not evidenced and regression-produced intercepts were close to zero. In conclusion, dividing by lean body mass is a valid method of comparing lifting capacity of males and females. However, ratio normalization should not automatically be used to compare performance scores of groups or individuals; its appropriateness should be evaluated first.

6. A new test was developed to determine external force and power generated during maximal-speed elbow extension. While lying supine, 10 men (21 yrs, 177 cm, 83 kg), were video-taped at 60 Hz as each horizontally threw balls of 0.91, 1.81, 3.63, and 5.44 kg at maximal velocity. Physical restraint ensured that elbow extension was the only movement used. Upper arm cross sectional muscle area (CSA) was estimated using an anthropometric equation. As ball mass increased: peak force on the ball increased but the angular displacement at which peak force occurred decreased; peak ball velocity decreased; time to reach peak ball velocity increased; time to reach peak power increased; and peak rate-of-change of force decreased. Peak power increased as ball mass increased to 3.63 kg, then decreased for the heaviest ball. CSA correlated much more highly than body mass with force, power, and force rate-of-change; correlations ranged from 0.47 to 0.72 and generally increased with ball mass. Correlations between peak force and peak power were 0.98, 0.94, 0.92, and 0.81 for the increasingly heavy balls. Peak forces on the ball were most highly correlated for balls closest in mass. Peak force and peak rate-of-change of force were highly correlated (0.94-0.99). The video analysis testing appears to be effective for assessment of movement-specific instantaneous force and power capability.

PUBLICATIONS:

1. Duggan, A. and J.F. Patton. Oxygen cost of treadmill and road running. In: Proceedings of the Ergonomics Society. E.J. Lovesey (Ed.), Taylor and Francis, London, 358-363, 1993.

2. Friedl, K.E., R.J. Moore, L.E. Martinez-Lopez, J.A. Vogel, E.W. Askew, L.J. Marchitelli, R. Hoyt and C.C. Gordon. Lower limit of body fat in healthy active men. J. Appl. Physiol. (In press), 1993.

3. Friedl, K.E. Body composition, physical performance, and anabolic and catabolic hormones. In: Review of the Results of Nutritional Intervention, Ranger Training Class 11/92. Committee on Military Nutrition Research. National Academy Press, Washington, D.C., 105-123, 1993.

4. Friedl, K.E., J.A. Vogel, L.J. Marchitelli and S.L. Kubel. Assessment of body composition changes by dual-energy X-ray absorptiometry. In: Human Body Composition, K.J. Ellis, J.D. & Eastman (eds.), New York: Plenum Press, 99-103, 1993.

5. Harman, E.A. Strength and power: a definition of terms. National Strength and Conditioning Association J. 15:18-20, 1993.

6. Johnson, M.J., K.E. Friedl, P.N. Frykman and R.J. Moore. Loss of muscle mass is poorly reflected in grip strength performance in healthy young men. Med. Sci. Sports and Exerc. (In press), 1993.

7. Kraemer, W.J., S.J. Fleck, J.E.Dziados, E.A. Harman, L.J. Marchitelli, S.E. Gordon, R.P. Mello, P.N. Frykman, L.P. Koziris and N.T. Triplett. Changes in hormonal concentrations after different heavy-resistance exercise protocols in women. J. Appl. Physiol. 75:450-459, 1993.

8. Martinez-Lopez, L.E., K.E. Friedl, R.J. Moore and T.R. Kramer. A longitudinal study of infections and injuries of Ranger students. Military Medicine 158:433-437, 1993.

9. Rice, V.J. and M.A. Sharp. Prediction of stretcher-carrying performance. Work: A Journal of Prevention, Assessment, and Rehabilitation. (In press), 1993.

10. Rice, V.J. Ergonomics and health care. Work: A Journal of Prevention, Assessment, and Rehabilitation. (In press), 1993.

11. Rice, V.J. and H.L. Snyder. The effect of benadryl and hismanal on psychomotor performance and perceived performance. Aviat. Space and Environ. Med. 64:726-734, 1993.

12. Rice, V.J. and H.L. Snyder. The effect of benadryl and hismanal on mood, physiological measures, antihistamine detection, and subjective symptoms. Aviat. Space and Environ. Med. 64:717-725, 1993.

13. Sharp, M.S. Physical fitness, physical training and occupational performance of men and women in the US Army: A review of literature. USARIEM Technical Report No. TN 93-7, July 1993.

14. Sharp, M.A., E.A. Harman, B.E. Boutilier, M.W. Bovee and W.J. Kraemer. Progressive resistance training program for improving manual materials handling performance. Work 3:62-68, 1993.

15. Sharp, M.A., V.J. Rice, B.C. Nindl and T.L. Williamson. Maximum team lifting capacity as a function of team size. USARIEM Technical Report No. T94-3, October 1993.

16. Sharp, M.A., V.J. Rice, B.C. Nindl and T.L. Williamson. Maximum lifting capacity in single and mixed gender three-person teams. In: Proceedings Human Factors Society 37th Annual Meeting. Santa Monica, CA, pp. 735-738, 1993.

17. Allison, S., K.A. Westphal and K. Finstuen. Thigh girth asymmetry as related to strength loss. J. Orthopedics and Sports Physical Therapy. 18:661-666, 1993.

ABSTRACTS:

18. Bidwell, T.E., J.F. Patton, M.E. Harp, R.P. Mello and M.M. Murphy. Effects of a chemical protective ensemble on the energy cost of incremental treadmill exercise. Med. Sci. Sports and Exercise. 25:S138, 1993.

19. Frykman, P.N., E.A. Harman, K.H. Han, J.J Knapik and J. Staab. Instantaneous force and power during rapid elbow flexion against four inertial resistances. J. Strength and Conditioning Res. 7:180, 1993.

20. Frykman, P.N., B.C. Nindl, K.E. Friedl, E.A. Harman and R.L. Shippee. Effects of extended physical training and caloric deficit on power output of young healthy males. Med. Sci. Sports and Exercise. 25:S58, 1993.

21. Harman, E.A., P.N. Frykman, K.H. Han, J.J Knapik and J. Staab. Force and power generated during high speed elbow extension. J. Strength and Conditioning Res. 7:180, 1993.

22. Harman, E.A., K.Han, P. Frykman, M. Johnson and M. Rosenstein. The effects of walking speed on the kinematics of backpack load carriage. Med. Sci. Sports and Exercise. 25:S116, 1993.

23. Harman, E.A., K. Han, P. Frykman, M. Johnson, F. Russell and M. Rosenstein. Effects of load carriage speed on muscle torques about the ankle, knee and hip. J. Biomechanics. 26:336, 1993.

24. Han, K., E.A. Harman, P. Frykman, M. Johnson and M. Rosenstein. The effects of four different backpack loads on the kinematics of gait. Med. Sci. Sports and Exercise. 25:S116, 1993.

25. Han, K., E. Harman, P. Frykman, M. Johnson, F. Russell and M. Rosenstein. The effects of various backpack loads on lower body joint torques. J. Biomechanics. 26:354, 1993.

26. Murphy, M.M., J.F. Patton, R.P. Mello, M.E. Harp and T.E. Bidwell. Physiological impact of wearing a chemical protective ensemble (CBE) during occupational task performance of men and women. Med. Sci. Sports and Exercise. 25:S138, 1993.

27. Nindl, B.C., B.H. Davis, M.T. Mahar, E.A. Harman and J.F. Patton. Adolescent male vs female upper and lower body anaerobic performance: controlling for anthropometric differences. Med. Sci. Sports and Exercise. 25:S189, 1993.

28. Nindl, B.C., E.A. Harman, M.T. Mahar and J.F. Patton. Anthropometric predictors of anaerobic power of male and female adolescent athletes. Pediatric Exercise Science. 5:451, 1993.

29. Nindl, B.C., M.A. Sharp and E.A. Harman. The validity of using strength scores divided by fat free mass to compare lifting capacities of men and women. J. Strength and Conditioning Res. 7:183, 1993.

30. Sharp, M.S., V.J. Rice, B. Nindl and T.L. Williamson. Effects of gender and team size on floor to knuckle height one repetition maximum lift. Med. Sci. Sports and Exercise. 25: S137, 1993.

PRESENTATIONS:

31. Harman, E.A. Current evidence on the use of lifting belts to prevent back injury among manual workers. 21st Annual Safety Conference of State Safety Managers and Occupational Health Managers, Scottsdale, AZ, 14-15 January 1993.

32. Harman, E.A. Reduction in health risk factors associated with resistance training. Sargent College, Boston University, November 1993.

33. Harman, E.A. Range-of-motion and speed specificity in resistance training. Noll Laboratory, The Pennsylvania State University, November 1993.

34. Patton, J.F. Physical training and Fitness in the Military. Walter Reed Army Medical Center, Washington, D.C. April 1993.

35. Rice, V.J. and J. Pentikis. Ergonomics II - Job Analysis. US Army Environmental Hygiene Agency, Towson, MD, November 1993.

36. Rice, V.J. Ergonomic Job Analysis - Tools of the Trade. The National Conference on Rehabilitation Management and Technology, Ft. Lauderdale, FL, September 1993.

37. Rice, V.J. and J. Pentikis. Ergonomics II - Job Analysis. US Army Environmental Hygiene Agency, Towson, MD, August 1993.

38. Rice, V.J. Ergonomic Research and Policy in the US Army. Military Environmental and Preventive Medicine Conference, USARIEM, Natick, MA, May 1993.

39. Sharp, M.A. Maximum lifting capacity in single and mixed gender three-person teams. New England Human Factors and Ergonomics Society, Natick, MA, November 1993.

40. Westphal, K.A. The application of physiology to physical therapy. American Physical Therapy Association, Cincinnati, Ohio, May, 1993.

KEY BRIEFINGS:

41. Karl E. Friedl, Ph.D., MAJ, MS. Brief of USARIEM study "Health, Performance and Nutritional Status of US Army Women during Basic Training" to Ft. Jackson personnel, Columbia, SC 23-24 February 1993.

42. Kathleen A. Westphal, Ph.D., LTC, SP. Brief of USARIEM study "Health, Performance, and Nutritional Status of US Army Women during basic Training" to Ft. Jackson personnel, Columbia, SC, 23-24 February 1993.

43. Kathleen A Westphal, Ph.D., LTC, SP. Brief BG Mitchener and TRADOC HQ staff on the Fort Jackson Women's Research study, Ft. Monroe, VA, 26 January 1993.

44. Karl E. Friedl, Ph.D., MAJ, MS. Brief BG Mitchener and TRADOC HQ staff on the Fort Jackson Women's Research study, Ft. Monroe, VA, 26 January, 1993.

SIGNIFICANT TDY:

Karl E. Friedl, Ph.D., MAJ, MS. To attend the Food and Nutrition Board's Committee on Military Nutrition Research meeting, Washington, D.C., 14-15 march 1993.

Everett A. Harman, Ph.D. To attend an executive board meeting of the National Strength and Conditioning Association, Las Vegas, NV, 1-3 April 1993.

Everett A. Harman, Ph.D. To participate in data collection for a study on parachute landing with the US Army Research Lab, Aberdeen Proving Ground, MD, 17 February 1993.

Everett A. Harman, Ph.D. To attend the executive board meeting of the National Strength and Conditioning Association, Omaha, NE, 6-10 January 1993.

Louis J. Marchitelli, M.A. To attend the basic and intermediate SPSS for Windows courses, New York, NY, 25-31 October 1993.

Bradley C. Nindl, SGT. To attend Primary Leadership Development Course, Ft. Knox, KY, 15 November - 15 December 1993.

John F. Patton, Ph.D. To attend Personnel Management for Executives course, Ft. Leavenworth, KS, 13-24 September, 1993.

Valerie J. Rice, Ph.D., LTC, SP. To attend Health Hazards Assessment Program working meeting, Ft. Detrick, MD, 16 April 1993.

Valerie J. Rice, Ph.D., LTC, SP. To attend Personnel Management for Executives course, Lancaster, PA, 11-25 June, 1993.

Valerie J. Rice, Ph.D., LTC, SP. To attend Army Medical Specialist Corps Combined Management Course, Chantilly, VA,

Valerie J. Rice, Ph.D., LTC, SP. To attend the Health Hazards Assessment Program working meeting, Ft. Detrick, MD, 1-2 December 1993.

Kathleen A. Westphal, Ph.D., LTC, SP. To attend Personnel Management for Executives course, Lancaster, PA, 26 October - 5 November 1993.

Kathleen A. Westphal, Ph.D., LTC, SP. To attend the AMSC Mary E. Hamrick Research course, Washington, D.C., 1-7 August, 1993.

Kathleen A. Westphal, Ph.D., LTC, SP. To serve as a member of the OTSG Accession Boards, Washington, D.C. 1-5 May 1993.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Patton, John F., Ph.D., Division Chief. Clinical Instructor, Department of Physical Therapy/Exercise Science, SUNY, Buffalo, NY. Associate Editor, Journal of Strength and Conditioning Research; National Strength and Conditioning Association Journal; Reviewer, Aviation, Space and Environmental Medicine; Military Medicine; Medicine and Science in Sports and Exercise; Journal of Applied Physiology.

Harman, Everett A. Ph.D., Research Physiologist. Adjunct Assistant Professor, Boston university. Vice-President for Basic and Applied Research, and Member, Tests and Measurements, and Research Committees, National strength and Conditioning Association. Member, Awards Committee, New England Chapter, American College of Sports Medicine. Senior Editor, Journal of Strength and Conditioning Research. Associate Editor, National Strength and Conditioning Association Journal. Reviewer, Medicine and Science in Sports and Exercise.

Rice, Valerie, J., Ph.D., LTC, SP, Occupational Therapist. Member, Army Medical Specialist Corps Research Advisory Group and Mentorship Program. Representative to the American Occupational Therapy Association Roster of Accreditation Evaluators. Chair, Advisory Committee for the Board of Certification in Professional Ergonomics. Reviewer, American Occupational Therapy Association, Book Reviewer, Ergonomics Society.

Sharp, Marilyn A., MA, Research Health Exercise Scientist. Abstract Reviewer, American College of Sports Medicine.

Westphal, Kathleen A., Ph.D., LTC, SP. Research Physical Therapist. Chief, Army Medical Specialist Corps Investigation and Research.

RESEARCH PROGRAMS AND OPERATIONS DIVISION

SIGNIFICANT PROFESSIONAL ACTIVITIES:

1. The Research Programs and Operations Division processed, staffed and coordinated 16 human use, 3 animal use and 5 study protocols.

2. During CY93, 57 manuscripts, 22 technical reports, 9 technical notes, 10 presentations, 3 posters, 108 abstracts and 3 book chapters were cleared.

PUBLICATION:

1. Thompson, K.J., M.P. Hamlet, B.H. Jones and J.J. Knapik. Impact of sock systems on frequency and severity of blister injury in a Marine recruit population. USARIEM Technical Report No. T6-93, 1993.

ABSTRACT:

2. Hamlet, Murray P. Accidental Hypothermia. Fifth European Congress on Extra-Corporeal Circulation Technology, Arles, France, 9-13 June 1993.

PRESENTATION:

Hamlet, Murray P. Frostbite and Non-Freezing Cold Injuries and Field Management and Thermal Stabilization of the Cold Patient. Wilderness Medicine Society, Sun Valley, Idaho, 20-24 March 1993.

Hamlet, Murray P. Accidental Hypothermia. Fifth European Congress on Extra-Corporeal Circulation Technology, Arles France, 12 June 1993

SIGNIFICANT TDY:

Hamlet, Murray P., D.V.M. To present Cold Weather Survival Class, Ft. Bragg, NC, 19-20 January 1993.

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Hamlet, Murray P., D.V.M. To present sock study data at the Marine Corps System Command, Quantico, VA, 22 January 1993.

Hamlet, Murray P., D.V.M. To confer on future sock development for soldier use, Senneca, NY, 25-26 January 1993.

Hamlet, Murray P., D.V.M. To attend the Naval Special Warfare Research and Development Conference, Panama City, FL, 8-11 February 1993.

Hamlet, Murray P., D.V.M. To speak at the Wilderness Medicine Society Meeting on Frostbite and Non-Freezing Cold Injuries and Field Management and Thermal Stabilization of the Cold Patient, Sun Valley, ID, 20-24 March 1993.

Hamlet, Murray P., D.V.M. To senior military personnel at the Marine Corps Recruit Depot on the sock study, Parris Island, SC, 31 March - 2 April 1993.

Hamlet, Murray P., D.V.M. To attend and speak on Accidental Hypothermia at the Fifth European Congress on Extra-Corporeal Circulation Technology, Arles, France, 9-13 June 1993.

Hamlet, Murray P., D.V.M. To attend the Special Operations Exposition and Trade Show, Fayetteville, NC, 12-15 July 1993.

Hamlet, Murray P., D.V.M. To attend seminar on Patent Law for Managers, Engineers and Scientists, Northbrook, IL, 22-26 August 1993.

Hamlet, Murray P., D.V.M. To present a cold weather siminary at the Cold Regions Research Laboratory, Hanover, NH, 28 September 1993.

Hamlet, Murray P., D.V.M. To lecture on cold weather injuries to student military at Norwich University, Norwich, VT, 3-4 December 1993.

Hamlet, Murray P., D.V.M. To attend the Soldier Survivability Conference, Arlington, VA, 6-8 December 1993.

Burse, Richard L., Sc.D. To attend the Federal Laboratory Consortium Northeast Regional Meeting as USARIEM's Technology Transfer respresentative, Southwest Harbor, ME, 28-30 June 1993.

Burse, Richard L., Sc.D. To participate in the USAMRDC Acquisition Management Liaison Officer meeting, Ft. Detrick, Frederick, MD, 30 August - 1 September 1993.

Modrow, Harold E. III, Ph.D., MAJ, MS. To attend P^2NBC^2 Joint Working Group, Ft. McClellan, AL, 20-23 January 1993.

Modrow, Harold E. III, Ph.D., MAJ, MS. To attend the Special Operations Exposition, Tampa, FL, 22-25 March 1993.

Modrow, Harold E. III, Ph.D., MAJ, MS. To serve as a judge for the 44th International Science and Engineering Fair, Gulfport, MS, 9-12 May 1993.

Modrow, Harold E. III, Ph.D., MAJ, MS. To attend the STAR 21 outbriefing, Washington, DC, 21 May 1993.

Modrow, Harold E. III, Ph.D., MAJ, MS. To attend the Personnel Management for Executive Course, Lancaster, PA, 15-25 June 1993.

Watson, Charles E., D.V.M., CPT, VC. To attend the American Veterinary Medical Association meeting, Minneapolis, MN, 17-21 July 1993.

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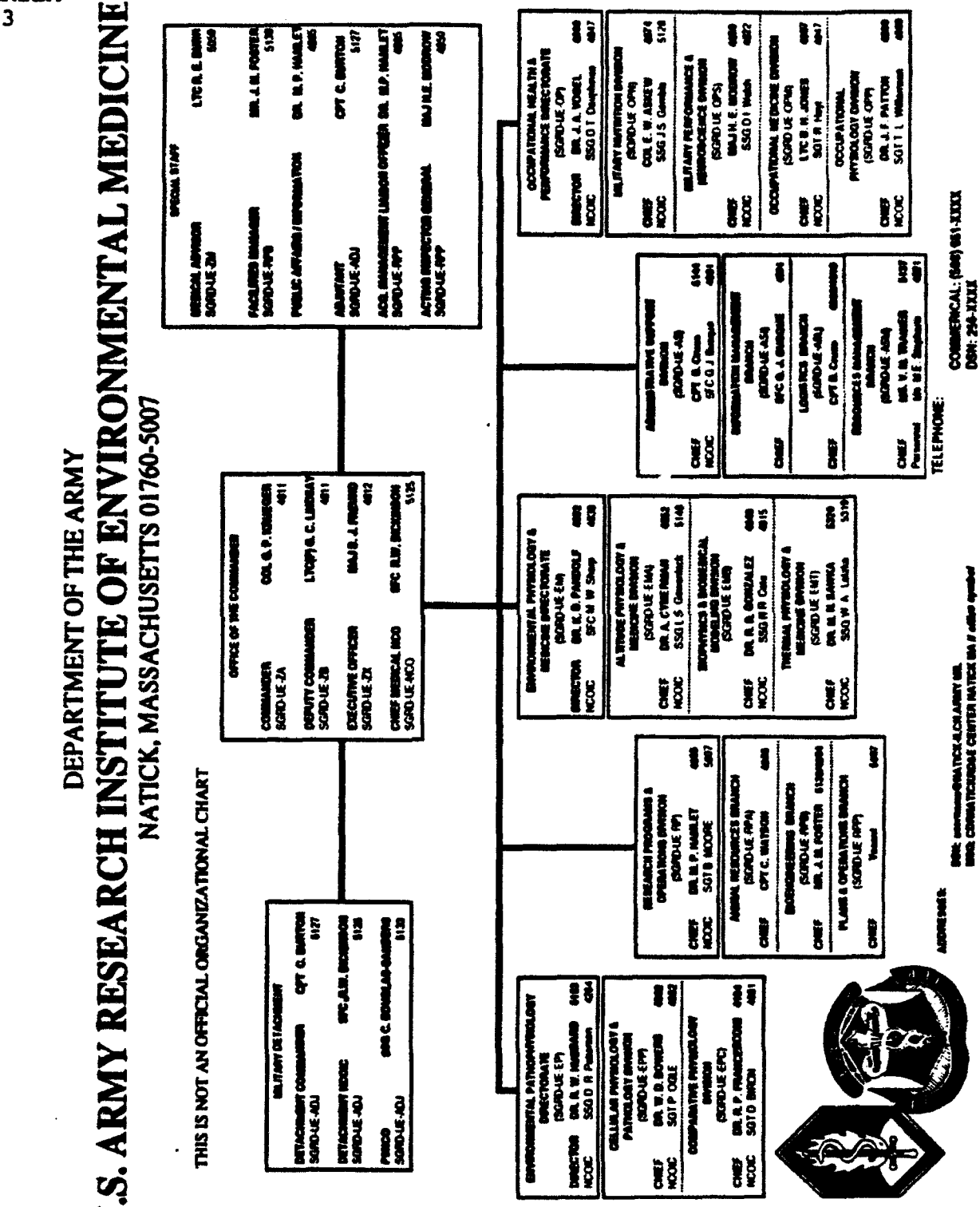
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